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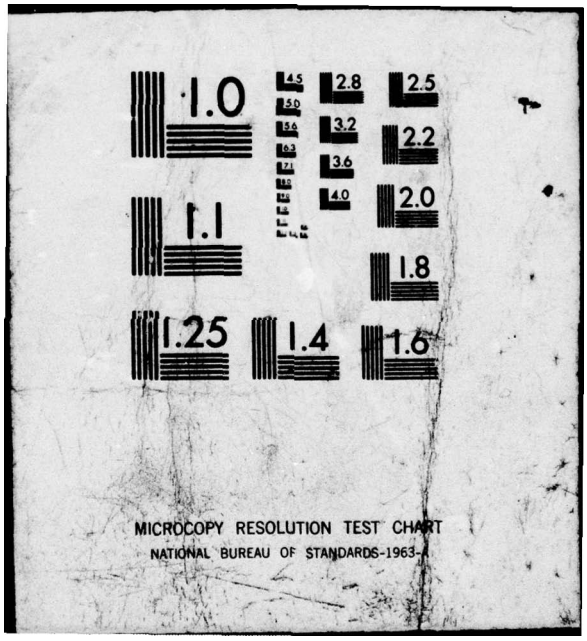
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Report No.

VOLUME I OF III

QUALIFICATION STANDARDS FOR PERSONNEL RESPONSIBLE FOR HAZARDOUS OR NOXIOUS CHEMICALS IN BULK

BY:

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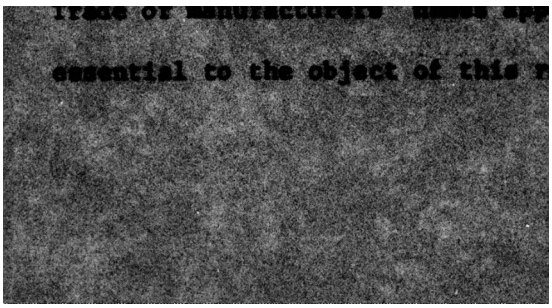
MAY 1976

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590



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15. Supplementary Notes

Volume I contains body of report, plus Appendices A through I; Volume II contains Appendix J; and Volume III contains Appendix K.

16. Abstract

The report is an analysis of personnel tasks on vessel systems transporting bulk hazardous and noxious chemicals. The recommendations relate to qualifications and training of chemical handling personnel aboard tankships and tank barges for two cargo containment systems (i.e., ambient-pressure-ambient temperature, and high pressure-ambient temperature). Topics discussed are initial personnel certification, renewal of certification, time frame for renewal and retraining. One of the results of this study is a data bank of tasks performed by marine personnel handling bulk chemical cargo (bound separately as Appendices J and K). In addition, an educational curriculum guideline was developed that may be useful to anyone interested in designing a training program for marine chemical handling personnel.

17. Key Words	18. Distribution Statement
Hazardous Materials Transportation by Water; Human Factors; Functional Job Analysis; Tank Ship; Tank Barge; Chemical Tankerman, Educational Curriculum; Personnel Training and Qualifications	

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PREFACE

It is probable that technical advances in marine transportation systems may have exceeded human capabilities in some instances, and therefore more attention should be devoted to human factors research. The Coast Guard sponsored human factors analysis being done by ORI is a large step in the right direction towards reducing human error in marine transportation.

This study was performed under the general direction of Mr. Leonard A. Stoehr, Program Director, by Dr. Paul A. Martino, Principal Investigator. The method of analysis used in this study is called Functional Job Analysis (FJA), a technique developed by Dr. Sidney Fine, a specialist in human factors and job analysis. Dr. Fine, as a consultant to ORI, trained ORI team members in the application of FJA, and also provided constructive criticism throughout the period of study which greatly contributed to the analysis. His enthusiasm and personal interest in this study is appreciated. Also, Ms. Janice Smith's assistance in the development of task statements and the task designator-curriculum matrix is appreciated.

EXECUTIVE SUMMARY

INTRODUCTION

This is a final report on the analysis of personnel tasks on vessel systems transporting bulk hazardous and noxious chemicals. The analysis was conducted as Task 3 of Human Factors Requirements Contract No. DOT-CG-41903-A.

The primary objective of the analysis is the development of a set of qualification standards for personnel responsible for safe handling of hazardous chemicals transported in bulk by tankships and tank barges. One of the results of this study is a data bank of tasks performed by marine personnel handling bulk chemical cargo.

In addition, the study developed an educational curriculum guideline that may be useful to Coast Guard evaluators when they examine proposed chemical handling personnel training programs.

One of the key findings as a result of this study is that chemical cargo tankermen should be certified for the type of chemical cargo containment and handling system (i.e., ambient pressure-ambient temperature, high pressure-ambient temperature, etc.). In addition, the level of personnel qualifications and training is dependent on: (1) special chemicals having unique or unusual handling procedures (e.g., chlorine, ethylene oxide, etc.), (2) the type of vessel (e.g., tankship, tank barge, etc.), and (3) class of vessel (i.e., cargo size). The importance of distinguishing containment systems will be borne out in the text of this report. The class of vessel is

important because as chemical cargo size increases, so does the magnitude of hazardous cargo accidents. Also, larger cargo loads usually require faster handling rates to reduce vessel turnaround time, which increases the likelihood of accidents due to human error. Cargo containment system complexity varies with vessel type, which implies that training and qualification of personnel must vary accordingly to assure proficiency and competence.

In general, the Coast Guard should qualify chemical cargo handling personnel on the basis of satisfactory completion of training. The level of training should reflect the degree to which the personnel are involved with the chemical cargo. The training should include a general understanding of the safety principles involved in bulk chemical transportation, as well as all the hazards an individual may encounter during bulk chemical cargo handling operations. A period of practical experience in applying these principles should be required for a particular containment system. This analysis consists of tasks performed by the person-in-charge of bulk chemical handling operations aboard tank vessels. Levels of training are also defined for other personnel.

The general recommendations in this summary relate to qualifications and training of personnel responsible for handling bulk chemical cargo on two bulk chemical cargo containment systems (i.e., ambient pressure-ambient temperature, and high pressure-ambient temperature). The recommendations address such topics as initial personnel certification, renewal of certification, time frame for renewal, and retraining.

RECOMMENDATIONS

1. Certification of chemical cargo tankermen should be tied not only to regulatory dangerous cargo classifications (i.e., flammable liquids, combustible liquids, compressed gases, etc.), but moreover, to types of chemical cargo containment systems (e.g., ambient pressure-ambient temperature, high pressure-ambient temperature, etc.).
2. Distinct endorsements to a certificate should be required for handling "special" chemicals having unique or unusual

hazards and handling procedures. Selection of these "special" chemical cargoes should be based on a scientific approach. That is, it should be based on a consistent reliable hazard rating. Further research should be conducted to establish an acceptable criterion.

3. Certificate endorsements should be required for handling bulk chemicals on different types of vessels (i.e., tankship, tank barge, other) and class of vessel (i.e., cargo size), because chemical cargo containment complexity varies with vessel type and the potential of cargo accidents increases with cargo size.

4. Initial certification should be based on (1) completion of an approved formal shoreside training program and (2) written evidence from a responsible member of industrial management, stating that the applicant has learned to operate cargo handling controls and equipment in a competent and safe manner. Satisfactory completion of a Coast Guard administered examination may be substituted for (1).

5. To maintain a high level of safety, the Coast Guard should require an applicant for initial certification to demonstrate his ability to read and understand the English language before issuing a chemical cargo tankerman's certificate.

6. Renewal of certification should be required when there is a one-year lapse in chemical cargo handling experience. Formal shoreside training should be required prior to renewal of certification. If these recommendations are followed, there is no need to change the existing license renewal time frame requirement of five years to a more frequent one.

7. On-the-job training is a necessary condition, but not sufficient for maintaining a high level of safety. In addition, personnel should attend some type of formal shoreside chemical cargo handling training school on a periodic

basis to maintain a high level of proficiency. The training programs of such schools should be approved by the Coast Guard and approval should be based on an examination of courses, number of course hours, and training aids. (Recommended training curriculum outlines are presented in Appendices C and D.)

8. The use of a liquid cargo handling simulator at formal shoreside schools is recommended for refresher training and performance testing, especially for those chemical cargo officers assigned to tankships with centralized cargo control consoles. Recommendations concerning the scope of performance tests are given on page 11.

9. Where centralized cargo controls are utilized, the substance of on-the-job training should be in concert with not only the scope and degree of the hazards presented by the chemical cargo, but moreover, the operation of cargo equipment controls, reading and interpretation of gauges, chart recordings and other data displays. Cargo handling personnel should be taught to handle centralized controls in normal and abnormal situations according to prescribed procedures. Recommendations concerning content of prescribed procedures are on page 17.

10. Future training needs should be anticipated. For example, chemical tankships may someday be fitted with advanced centralized cargo control systems. Some systems will be set up with computers to control pumping operations, as well as compute vessel stability, trim and stress data for various cargo plans. Training requirements should include tests on how to operate such systems.

11. Applicants for initial certification as a chemical tankerman should be required to have sufficient experience. Active participation as an assistant to a qualified person

in a minimum number of chemical cargo transfers within a specified time frame would meet this requirement.

12. The number of chemical cargo transfers required of personnel to qualify them as having sufficient experience should be determined from known operations. The Coast Guard should seek the cooperation of chemical and marine transportation industry representatives through established rule-making procedures to formulate practical experience standards. As a first approximation, a minimum of six months apprenticeship as an assistant to a person holding an appropriate tankerman's license and participation in at least 12 relevant chemical cargo transfers (six loadings and six dischargings) should be sufficient experience on a tankship. The same experience for barge personnel is recommended; however, the six-month time period requirement should be waived or tied to a marine terminal rather than a vessel.

13. On-the-job training programs conducted either on a tankship or marine terminal should be designed to supplement formal shoreside training. Films and other visual aids should be used to indoctrinate personnel in specific characteristics of a chemical cargo handling system.

14. Terminal personnel responsible for loading and discharging bulk chemical vessels and shipyard personnel responsible for cleaning and gas-freeing bulk chemical vessels should be required to have a tankerman's license subject to the same special endorsements discussed in recommendations 2 and 3 in this listing.

15. Written operating procedures and checklists should be required on chemical tankers and terminals to improve bulk chemical handling safety. Checklists should be designed to assure a "systems approach" in the inspection of chemical cargo equipment and safety equipment. This

will facilitate the detection of material deterioration early enough to take corrective action. It is especially important to require a system's checklist for inspection of vessel equipment prior to transfer of chemical cargo.

16. Safety regulations are the main foundations on which operating procedures are built. It may be difficult for field personnel to formulate clear, concise and easily understood operating procedures, if the Federal regulations themselves present complications. Current maritime hazardous chemical regulations are difficult to interpret because they are scattered about in several subchapters of the Code of Federal Regulations. Another complicating factor is cargo handling operational requirements are intermingled with vessel construction and equipment specifications. The consolidation of Coast Guard regulations relating to bulk chemical cargo handling operations into a single cohesive set of regulations should alleviate these problems. The development of a handbook or guide describing these regulations in a form that can be easily read and understood by marine transportation chemical handling personnel would also be helpful.

17. Task analyses should be performed on the remaining two containment systems defined in this study (i.e., ambient pressure-low temperature, and ambient pressure-high temperature).

18. A study should be conducted to determine why personnel do not wear available protective gear when exposed to dangerous conditions during chemical cargo handling on tankships and barges.

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I. INTRODUCTION

The transportation of bulk hazardous chemical cargo presents complex problems for personnel responsible for cargo handling. Many of the chemicals have a variety of hazards, including reactivity, flammability, and toxicity. Another complicating factor that presents a potentially hazardous situation is the state of the chemical cargo during transport and handling. Some chemicals are handled as pressurized liquefied gas in high pressure cargo containment systems, while others are transported as cryogenic liquids, or as solids in a molten state at elevated temperatures.

In the analysis of personnel tasks being reported here, the first level of approach of the study team has been to differentiate the types of containment and handling systems in use today by specifying conditions of chemical cargo transport. When this is done, four distinct systems are defined:

1. Ambient pressure-ambient temperature
2. High pressure-ambient temperature
3. Ambient pressure-low temperature
4. Ambient pressure-high temperature.

The first and second containment systems are the only ones analyzed in this study.

In the ambient pressure-ambient temperature containment system, chemical liquid cargo is handled near atmospheric pressure (1 atmosphere)

and normal temperature (about 70° F). The chemical liquids are usually transported on conventional tankships in tanks that may be separated from each other by void spaces or tanks containing a mutually compatible cargo. High pressure-ambient temperature systems contain pressurized liquefied chemical gas cargo at or near the vapor pressure of the gas at ambient temperature. There are only a few pressurized liquefied gas tankships currently in use today. Pressurized liquefied gas cargo is usually transported in pressure vessel tanks on tank barges operating on the inland waterways of the United States.

It is possible to have more than one containment system or a combination of different systems aboard a single vessel; however, in the interest of efficiency and simplicity, this analysis considers only a single system for a particular vessel type. It was decided that the analysis could be best accomplished by assigning the ambient pressure-ambient temperature cargo containment system to a tankship and the high pressure-ambient temperature cargo containment system to an unmanned barge. Although there will be some variation in personnel tasks depending on whether the containment system is on a tankship or tank barge, the difference is considered negligible for the purposes of this study.

Typical chemicals transported by these two containment systems are listed in the tables of Appendices A and B. It should be noted that each chemical has a variety of hazards which are revealed in the National Academy of Sciences (NAS) hazard ratings, and also shown in the tables. It is of interest to note that in most cases, the federal regulatory classification for each chemical indicates only one hazard (which in general appears to have the highest NAS rating), but gives no indication of the other hazards a chemical may possess. This could be dangerously misleading because the regulatory classification points only to a primary hazard and masks other hazards which may be harmful to personnel responsible for handling the cargo. Personnel should be trained in <u>all</u> hazards they may encounter in handling bulk chemicals rather than, for example, a "flammable cargo tankerman" receiving training in only flammability hazards. Table 1 illustrates one way in which chemical cargo tankermen endorsements may be applied.

The method of analysis used in this study is Functional Job Analysis (FJA), developed by Dr. Sidney Fine, a specialist in human factors and job

TABLE 1

TANKERMAN CERTIFICATE ENDORSEMENTS FOR BULK CHEMICAL CARGO

TYPE	CHEMICAL CARGO CONTAINMENT SYSTEM	GENERALLY QUALIFIED TO HANDLE	SPECIAL QUALIFICATIONS		
			SPECIAL PRODUCTS	VESSEL TYPE	CARGO SIZE
TANKERMAN AP–AT	AMBIENT PRESSURE–AMBIENT TEMPERATURE	BULK CHEMICAL LIQUID CARGO TRANSPORTED NEAR AMBIENT PRESSURE (1 atm.)–AMBIENT TEMPERATURE (70°F).	CARBON DISULFIDE CHLOROSULFONIC ACID ETHYLENEIMINE MOTOR FUEL ANTI–KNOCK COMPOUNDS OLEUM	TANKSHIP, TANKBARGE, OTHER	OVER X TONS OR UNDER X TONS
TANKERMAN HP–AT	HIGH PRESSURE–AMBIENT TEMPERATURE	BULK PRESSURIZED LIQUIFIED CHEMICAL CARGO TRANSPORTED NEAR VAPOR PRESSURE OF GAS AT AMBIENT TEMPERATURE (70°F).	CHLORINE ETHYLENE OXIDE PROPYLENE OXIDE	TANKSHIP, TANKBARGE, OTHER	OVER X TONS OR UNDER X TONS

analyses. FJA was selected because it focuses on the functions of man-machine interactions, and it takes a systems approach of maintaining a broad perspective which is essential for the development of good recommendations relating to personnel training qualifications. The concepts and techniques of FJA are discussed very briefly in this report since they have been covered adequately elsewhere.[1]

ORGANIZATION OF THE REPORT

It was recognized in the later stages of the study that, due to great similarity in content, a single report would be more effective for the analysis of both containment systems. Therefore, both systems are covered in this report but treated separately whenever necessary to point out major differences. Recommendations relating to educational curricula for personnel handling bulk hazardous chemicals at ambient pressure and temperature, and at high pressure and ambient temperature are contained in Section II. Also, recommendations relating to operating procedures, safety regulations and checklists are discussed in Section II. A brief summary on how functional job analysis was applied in this study is contained in Section III. Recommended future analyses related to this work are discussed in Section IV.

To maintain clarity, functional job analysis task data and related information are included in the appendices. Typical chemical cargoes transported in each containment system (i.e., ambient temperature-ambient pressure, and high pressure-ambient temperature) are contained in Appendices A and B. Curriculum outlines for both containment systems are in Appendices C and D. Appendix E contains a bibliography of the literature reviewed on tanker chemical cargo equipment and procedures relating to bulk chemical cargo handling operations. Persons contacted in the chemical distribution and marine transportation field during this study are listed in Appendix F. The task statement scales of worker function, instruction level, and general educational development defined in

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[1] For a detailed discussion of FJA, see An Introduction to Functional Job Analysis, Sidney A. Fine and Wretha Wiley (1971); Functional Job Analysis, Sidney A. Fine, Ann M. Holt and Maret F. Hutchinson (1974); Functional Job Analysis Scales, Sidney A. Fine (1973); and Handbook for the Development of Qualifications for Personnel in New Technology Systems, ORI Technical Report 1012 (1976).

Functional Job Analysis Scales, A Desk Aid, by Sidney A. Fine are provided in Appendix I. The detailed task statements which describe tasks, performance standards, training and basic educational requirements for personnel handling chemical cargo are bound separately because of the large amount of data developed from an analysis of both containment systems. The task statements are contained in Appendices J and K.

II. RECOMMENDATIONS ON TRAINING

EDUCATIONAL CURRICULA

In addition to documentation of tasks, the analysis develops a curriculum outline which may be used as a guide by the Coast Guard when evaluating proposed chemical cargo handling training programs. The task statements themselves serve as detailed recommendations for training; however, this analysis extends the work of previous studies[2] to include a curriculum outline.

The first step in the curriculum design was to identify curriculum titles. This was accomplished by careful examination of the FJA task statements. The skills and knowledge shown on the task statements were compiled and grouped into clusters to derive course titles. Thus, the course titles are constructed directly from the task analysis developed in this study.

A list of recommended course titles for training personnel handling bulk chemicals for both containment systems is shown in Table 2. The key points and distinctions in personnel training requirements are highlighted in the discussion below.

The person-in-charge of chemical cargo handling is the only person required to have training in all the courses shown. The other chemical cargo

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[2] Recommendations for Qualifications of Liquefied Natural Gas Cargo Personnel, Operations Research, Inc., Technical Report 997, January 1976, and Recommendations for Qualifications of Engineering Personnel of Nuclear-Powered Ships, Operations Research, Inc., Technical Report 1011, 1976.

TABLE 2

RECOMMENDED COURSE TITLES

TRAINING	TRAINING RESOURCE				PERSONNEL		
Curriculum Course Titles	Shoreside Training School	Written Exam	O-J-T Training Vessel/Chemical Terminal	Simulation	Person-in-charge, Chemical Cargo Handling	Other Chemical Cargo Handling Personnel	Other Vessel Personnel
I. Chemical Properties, Hazards and Hazard Control							
A. Physical and chemical properties and characteristics	(16) x	x	o		x		
B. Chemical hazards	(24) x	x	o		x	x	x
C. Hazard detection and control	(16) x	x	o		x		
II. Containment Design Concepts and Safety Features							
A. Mechanical design features of chemical cargo containment and handling system	(8) o	o	x		x	x	
B. Design, components and functions of cargo containment control mechanisms	(8) o	o	x		x	x	
C. Components and functions of safety instrumentation and emergency systems	(8) o	o	x		x	x	
III. Chemical Cargo Equipment Operation and Maintenance							
A. Functions of chemical cargo control instrumentation	(40) o	o	x	x	x	x	
B. Purpose and operation of cargo equipment	(40) o	o	x		x	x	
C. Safety principles and procedures of equipment setup	(20) o	o	x		x	x	
D. Maintenance of chemical cargo and safety equipment	(20) o	o	x		x	x	
IV. Safety and Emergency Procedures							
A. Safety precautions during chemical cargo transfer operations	(16) x	o	x	x	x	x	
B. Fire fighting techniques and procedures for chemical fires	(16) x	o	x	x	x	x	x
C. Purpose and use of personnel protection and safety equipment	(16) x	o	x	x	x	x	x
D. First aid procedures	(16) x	o	x	x	x	x	x
V. Proper Procedures and Safety Precautions in Conformance with Government Regulations & Industry Safety Codes							
A. Purpose and content of Coast Guard dangerous cargo and water pollution regulations	(8) x	x	o		x		
B. Purpose and content of international shipping safety codes and guides	(8) x	x	o		x		
C. Purpose and content of industry codes and government safety guides	(8) x	x	o		x		

Notes: x = Primary Training Resource; o = Augments Primary Training; ( ) = Recommended Minimum Number of Class Hours

handling personnel perform lower level tasks and therefore require a lower level of training and qualification. The scope of their training is essentially the same as for the person-in-charge; however, they do not need a training course in:

- Proper procedures and safety precautions in conformance with government regulations and industrial safety codes.

Instead, they must be familiar with standard operating procedures based on current safety regulations. Also, it does not appear necessary for them to be knowledgeable in such areas as:

- Hazard detection and control
- Physical and chemical properties and characteristics.

It is assumed that tasks requiring knowledge in these subject areas will be performed by the person-in-charge. Other personnel associated with the vessel do not need as much training as cargo handling personnel, but they should have training in:

- Chemical hazards
- Fire fighting techniques and procedures
- Purpose and use of personnel protection and safety equipment.
- First aid procedures.

The delineation of testing and training procedures (i.e., shoreside training, on-the-job training, simulation and written examinations) is also shown in the table. It should be noted that classroom instruction is considered the best method for teaching courses in:

- Chemical properties, hazards and hazard control
- Proper procedures and safety precautions in conformance with government regulations and industrial safety codes.

In comparison, on-the-job training should be utilized for such courses as:

- Containment design concepts and safety features
- Chemical cargo equipment operations and maintenance.

Simulators can be used to increase personnel proficiency in standard operating procedures (and especially emergency procedures which rarely occur during actual operations). Simulators will enhance teaching methods for such courses as:

- Functions of chemical cargo control instrumentation
- Safety precautions during chemical cargo transfer operations.

The use of simulation warrants further discussion. It is known that chemical liquid cargo simulators are not available today at formal training schools. The Maritime Institute of Technology and Graduate Studies, Linthicum Heights, Maryland, has a liquid cargo simulator, but they do not have a program to train personnel in the many problems associated with bulk chemical liquid cargo handling. There are other alternatives which can be pursued. Modern chemical ships have cargo control consoles which can be used to simulate chemical loading/discharging operations. These facilities can be used for training, to ensure personnel and equipment are properly integrated through prepared procedures.

The subject of simulation leads to operational performance testing, which is a good training method to minimize operational errors. Hammer discusses operational errors and states that they are primarily control and procedural types.[3] Types of human errors generated by procedural problems include problems with the procedures themselves, "which may be lacking, incorrect, lengthy, awkward, poorly written and hard to understand."[4] Control errors occur even when a procedure is followed according to a specified plan. Indicators can be read incorrectly and evaluations or judgments can be based on inaccurate settings. A few examples of possible marine transportation chemical cargo accidents caused by control errors include:

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[3] Willie Hammer, Handbook of System and Product Safety, Prentice Hall, Inc., 1972.

[4] Ibid., p. 194.

- Cargo tank overflow due to an excessive loading rate during topping off operations.
- Mixing of reactive chemical cargoes due to pushing the wrong button on a cargo control console or opening the wrong valve.
- Cargo hose rupture caused by too fast a flow rate at the start of cargo transfer.

Performance tests should be designed to test the person's understanding of a particular cargo handling subsystem and his familiarity with the controls and operating procedures. They should be administered by a responsible representative of industry. The test should require the person to demonstrate an understanding of:

- Start-up procedures for chemical cargo transfer operations including the status of associated equipment which could affect the safety of chemical cargo handling operations (such as tankship engines, boilers, combustion equipment, other craft alongside the vessel, etc.).
- The instrumentation system and the significance of chemical cargo instrument readings.
- The manipulation of console controls required to bring the chemical cargo from start of flow conditions to designated steady state pumping rates and to topping off conditions.
- The significance of alarms and signals indicating an out-of-limits chemical cargo condition and response procedures for remedial action.
- The control manipulation required to obtain desired chemical cargo conditions during abnormal and emergency situations.
- The operation of systems coupled to the cargo handling operation such as ballasting, tank cleaning and gas-freeing.

Some type of simulation or role playing is also required for such courses as:

- Fire fighting techniques and procedures in chemical fires
- Purpose and use of personnel protection and safety equipment
- First aid procedures.

Personnel can learn fire fighting techniques by attending established shoreside fire fighting schools where they will have an opportunity to fight flammable liquid fires approaching nearly realistic conditions. In addition, personnel can learn how to use personnel protection equipment and administer first aid at such schools.

Also shown in the table are the recommended minimum number of classroom hours for each course. These are estimates based on known training programs currently offered at marine safety schools (e.g., fire fighting schools). No estimates were made on required number of instructors or class size because they vary widely depending on such factors as the number of applicants seeking training in a given locality. Instructors at these shoreside schools should be familiar with maritime operations, preferably have some prior maritime or naval experience and formal education in fundamentals of chemistry and physics. Merchant marine academies and union schools should have adequate facilities for the development and administration of chemical cargo handling training programs.

CURRICULUM DETAILS

The development of a detailed curriculum outline required synthesizing material from the literature with information specified in the task statements. The method described here produces the same course titles for both containment systems, but differences occur in the details of the curriculum outline. These differences are attributed primarily to dissimilar characteristics of the cargo in each system. In one case, we have a chemical liquid in its natural state at atmospheric pressure and normal temperature, and in the other, we have pressurized liquefied chemical gas at high pressure and ambient temperature. There are also differences because of variations in cargo handling equipment. For example, when transferring chemical liquid at ambient

pressure-ambient temperature, on a tankship, the person responsible for cargo handling operations will probably have to know how to operate cargo valves and controls to a deep-well cargo pump. The transfer of pressurized liquefied gas on a barge, on the other hand, may require knowledge of how to open a cargo valve on a barge to regulate the cargo flow from a shoreside compressor or vaporizer. It should be noted that the curriculum outline is essentially insensitive to whether the particular containment system is on a tankship or tank barge. Thus, the curriculum outline appears adequate for personnel handling bulk chemicals on both tank barges and tankships. A detailed curriculum outline for each cargo containment system is contained in Appendices C and D.

OPERATING PROCEDURES

A relationship between task distribution and FJA instruction level is shown as a histogram in Figure 1. The task distribution relating to general educational level in reasoning, math and language is shown in Figures 2 and 3. The figures show that most of the work is a combination of prescribed and discretionary tasks which require personnel to have good skills, a relatively high educational level and a great deal of work experience.

Caution should be exercised when conducting an analysis of data shown in these figures. For example, Figure 1 shows a greater number of discretionary tasks for the high pressure-ambient temperature containment system on a tank barge than for the ambient pressure-ambient temperature system on a tankship. This may not be true in all cases, and such a conclusion can be misleading and misrepresentative of the real world situation. It may be safe to say, however, that since a high percentage of tasks are more nearly prescriptive than discretionary, it follows that written operating procedures and checklists should be required on chemical tankers and terminals to improve bulk chemical handling safety.

Checklists should be designed to assure a "systems approach" in the inspection of chemical cargo equipment and safety equipment. This will facilitate the detection of material deterioration early enough to take corrective action. It is especially important to have a system's checklist available for inspection of vessel equipment prior to transfer of chemical cargo.

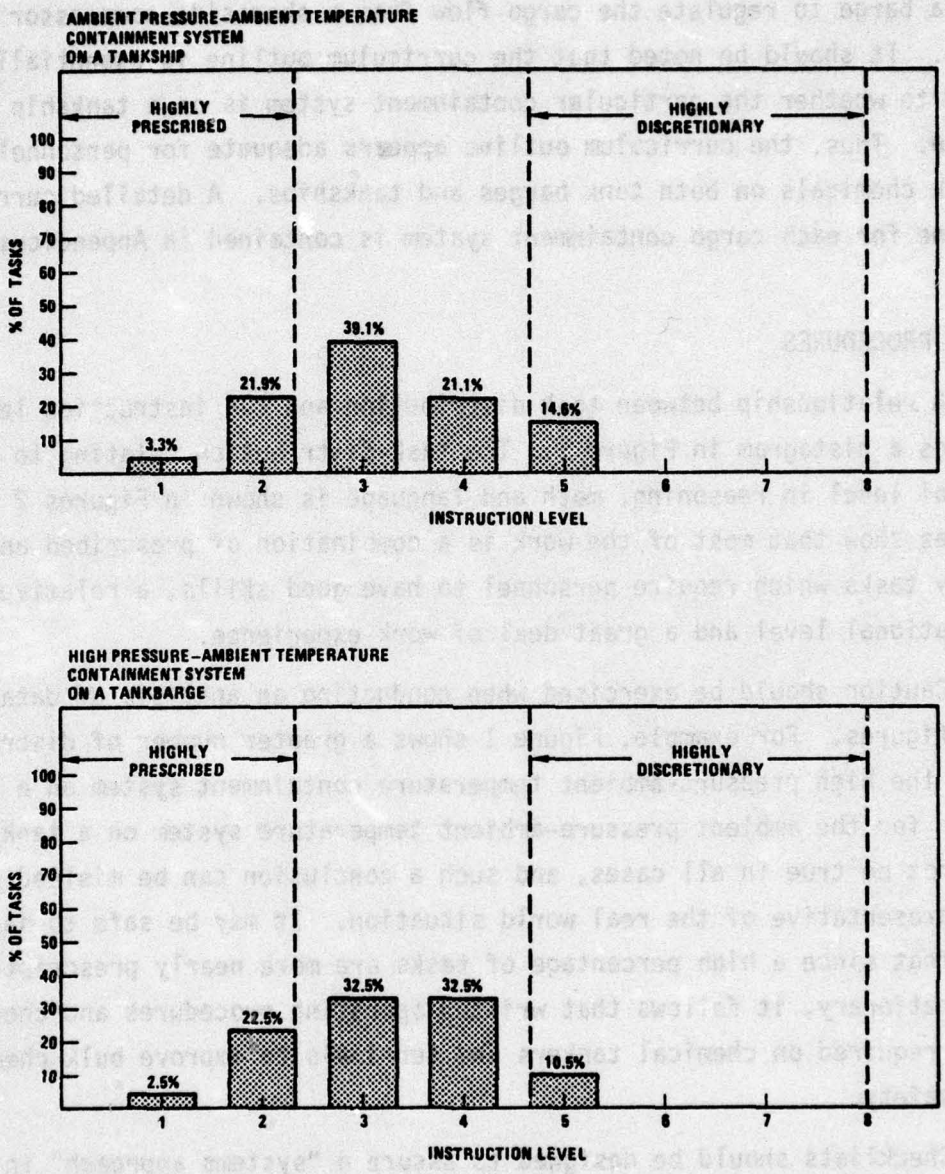

FIGURE 1. TASK DISTRIBUTION - INSTRUCTION LEVEL RELATIONSHIP

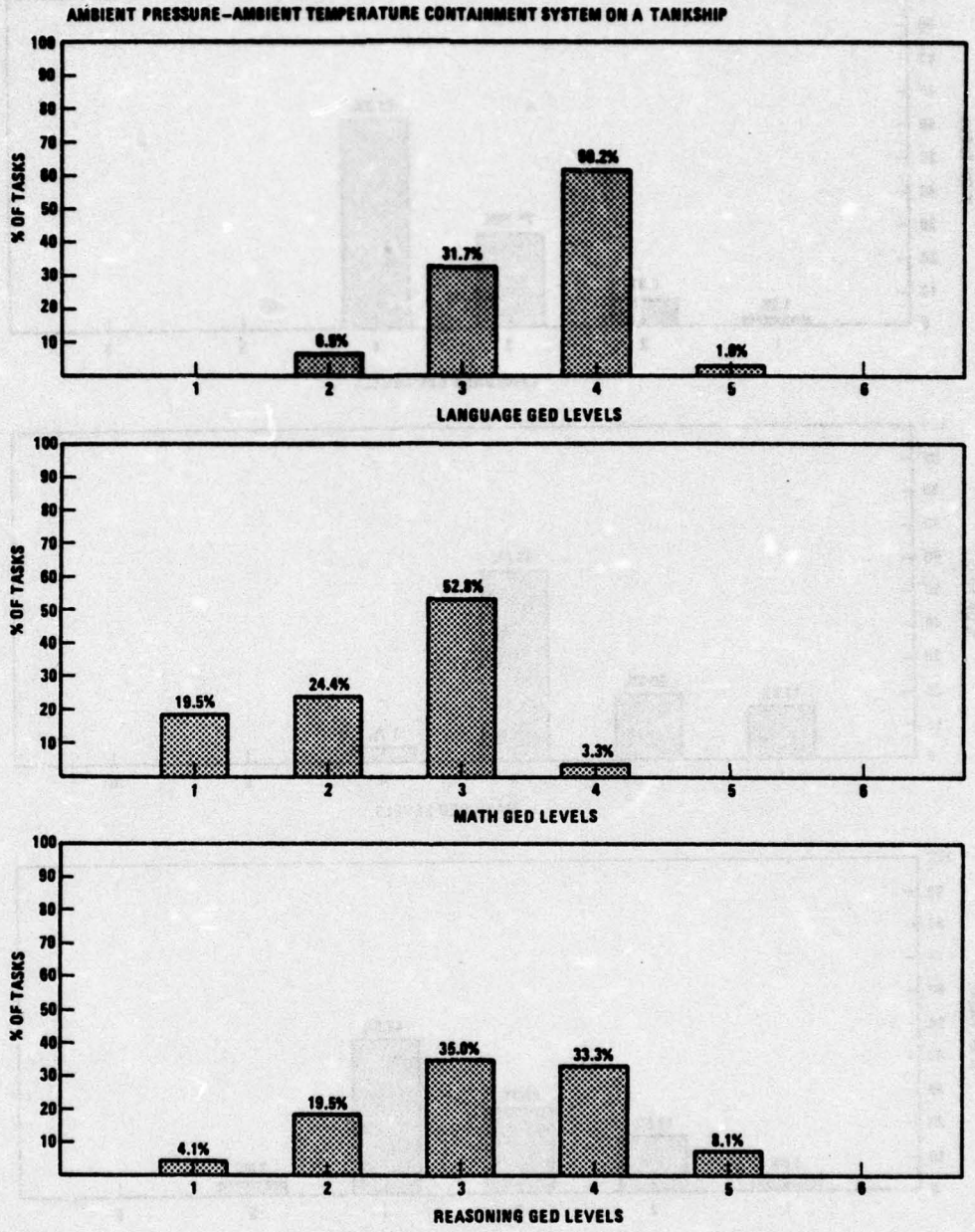

FIGURE 2. TASK DISTRIBUTION RELATING TO GED LEVELS IN REASONING, MATH AND LANGUAGE
(Ambient Pressure-Ambient Temperature)

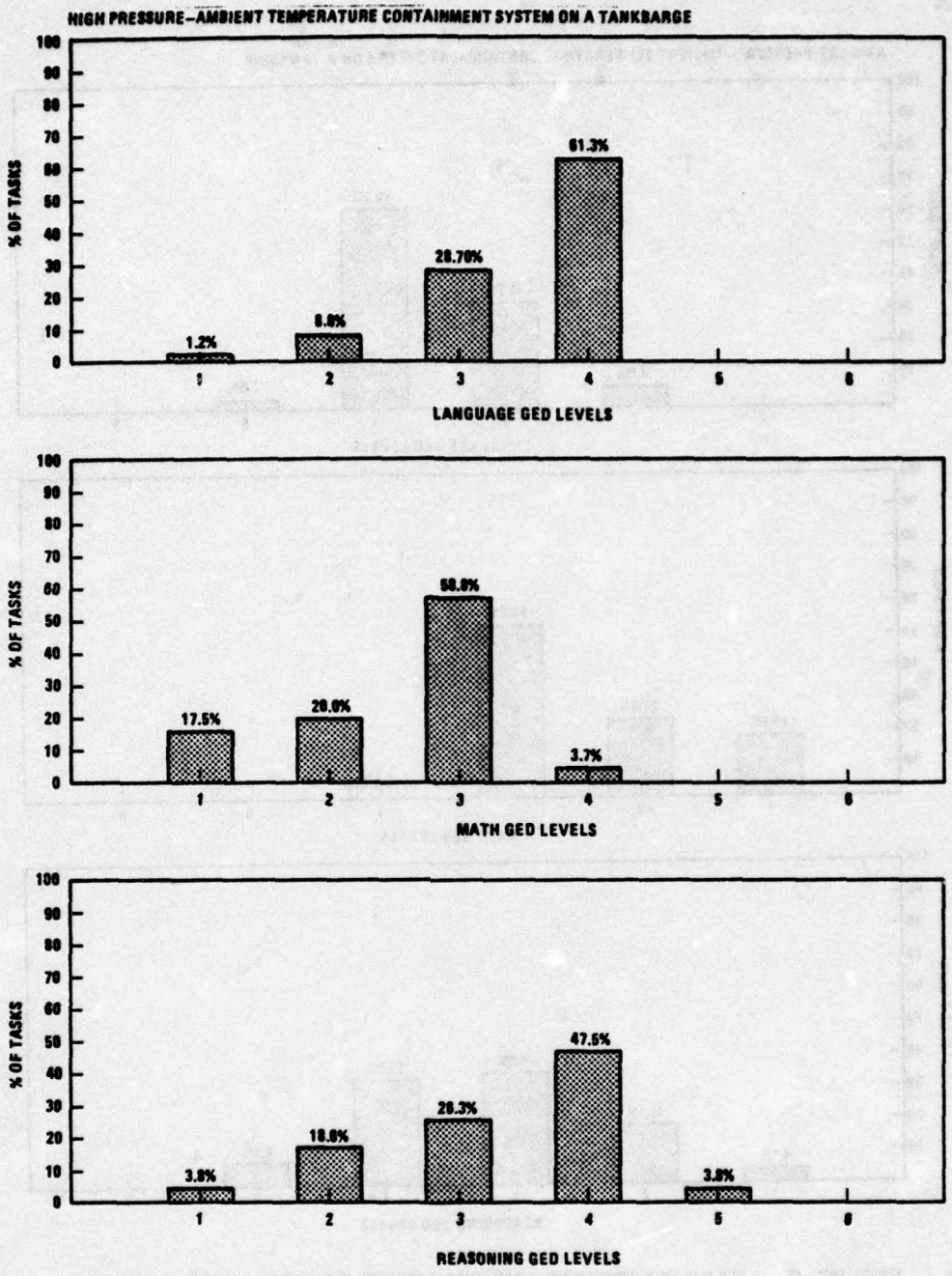

FIGURE 3. TASK DISTRIBUTION RELATING TO GED LEVELS IN REASONING, MATH AND LANGUAGE
(High Pressure-Ambient Temperature)

A written operating procedure is of primary importance when training chemical cargo handling personnel on the job. Operating procedures should include:

1. A general description of chemical hazards and precautionary measures to be followed.
2. The significance of chemical hazards including permissible levels of chemical vapor exposure to unprotected personnel.
3. An emergency plan for a particular chemical cargo containment system and duties assigned under the plan.
4. A detailed description of the required chemical cargo handling operating procedure, including labeling and color coding of controls and valves.
5. The specification of system variables, such as time, temperature and pressure.
6. A clear definition of each sequence with special hazards noted for each sequential operation.
7. A clear definition of operating instructions and emergency shut down procedures.
8. A procedure on when and how to report malfunctioning equipment, or an unsafe practice.

It should be mentioned here that while well-written operating procedures may be important, they do very little if personnel do not have the language ability to read and understand them. This analysis (Figures 2 and 3) shows that many tasks require a relatively high language ability (FJA rating of 4). An FJA language rating of 4 means that the individual in many cases should be able to understand technical manuals and verbal instructions, as well as drawings and specifications associated with chemical cargo handling operations.

One other important point should be made here concerning federal hazardous materials regulations. Safety regulations are the main foundations on which operating procedures are built. It may be difficult for field personnel to formulate concise and easily understood operating procedures, if the federal regulations themselves present complications. Current maritime

hazardous chemical regulations are difficult to interpret because they are scattered about in several subchapters of the Code of Federal Regulations. Another complicating factor is that cargo handling operational requirements are intermingled with vessel construction and equipment specifications. The consolidation of Coast Guard regulations relating to bulk chemical cargo handling operations into a single cohesive set of regulations should alleviate these problems. The development of a handbook or guide describing these regulations in a form that can be easily read and understood by marine transportation chemical handling personnel would also be helpful.

III. FUNCTIONAL JOB ANALYSIS

The following discussion summarizes how FJA was applied in this study. Much of the information presented here can be found in the Handbook for Development of Qualifications for Personnel in New Technology Systems, ORI Technical Report 1012, 1976. Excerpts from the Handbook are included here only in the interest of completeness.

METHODOLOGY OUTLINE

The procedure for developing training qualification requirements and licensing criteria for personnel in marine chemical handling systems can be subdivided into ten separate activities. These activities are illustrated in the flow chart shown in Figure 4. The figure is designed to point up the fact that although the ten activities are performed in sequence, there is a good deal of backflow during progress toward completion. System diagramming (Activity 2 in the figure) may point up a need for more information (Activity 1); so may the task editing activities send the analysts back for more information. Each step continues, is consulted, and is resumed as needed throughout the analysis.

Early in the study a literature review was conducted to examine the chemical cargo equipment in use on tankships and tank barges, as well as an examination of the procedures followed in chemical cargo handling operations.

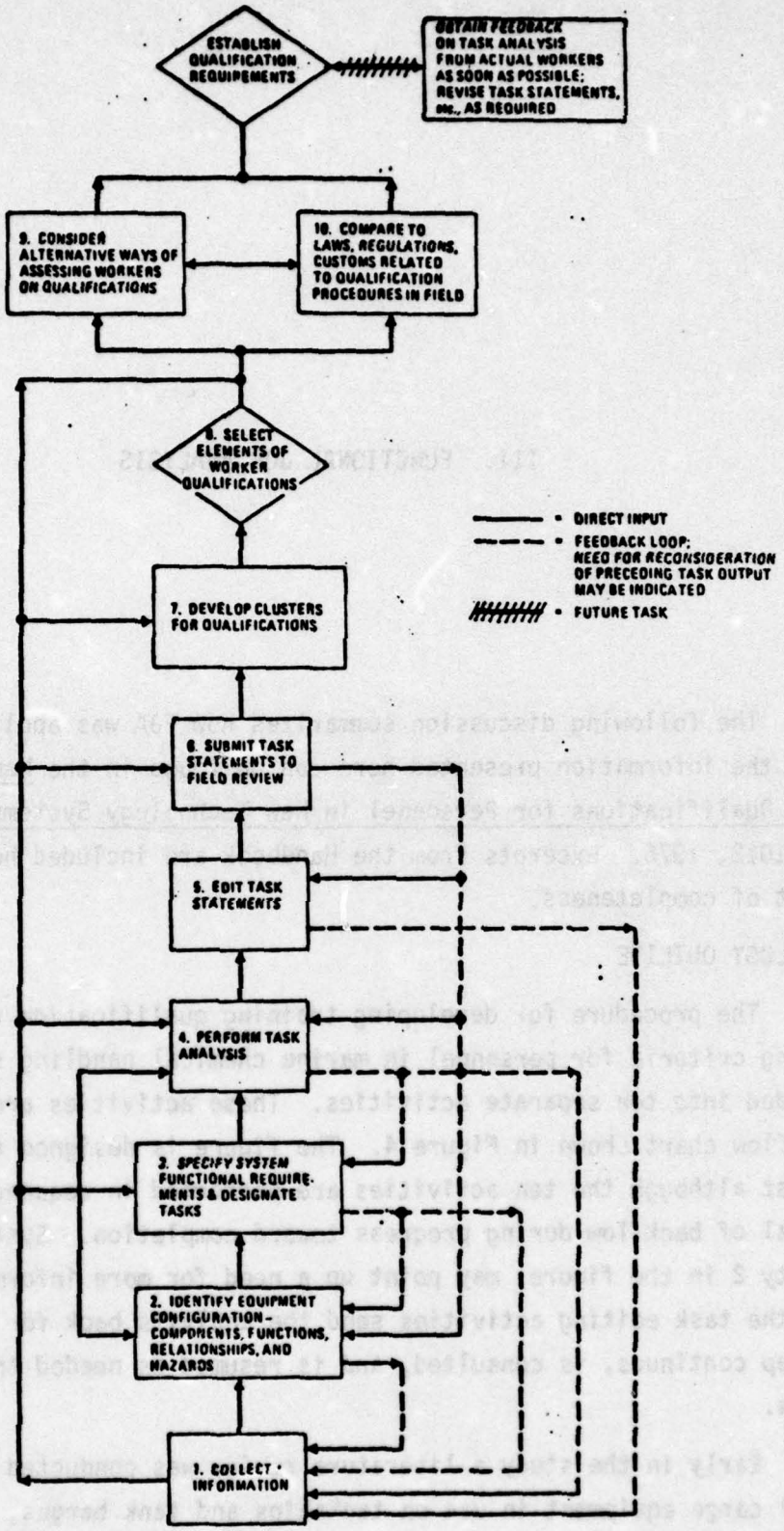

FIGURE 4. PROCESS FLOW CHART

A bibliography of this literature is presented in Appendix E. Other sources of information included interviews with chemical loading/discharging supervisors and marine department managers of major chemical companies. Appendix F contains a list of people contacted by telephone, mail, and person-to-person interviews. Written information in the form of operating manuals was received from Marine Transport Lines, Inc., and Socony Mobil Oil Company. EXXON International stated that they did not have any materials which they considered useful for this study. Hendy Brothers has extensive manuals based on a systems approach for handling vinyl chloride monomer; however, their manuals were not made available for proprietary reasons. Chemical distribution terminals, chemical tankers and tank barges were visited whenever arrangements could be made during this study. Information on specific chemical cargo handling operations were obtained through interviews of chemical cargo handling personnel and inspection of vessels, cargo equipment arrangements, and controls.

Visits to Dow Chemical Company's bulk chemical distribution terminal in Freeport, Texas, were extremely helpful. One of the largest bulk chemical distribution centers in the world, the facility handles a wide range of chemicals with a variety of hazards. Also, observations of personnel conducting cargo transfer operations aboard Union Carbide's chemical tanker, the ALASKAN, provided good data to improve task statement reliability.

Based on a review of the information gathered, a flow diagram of each containment system was developed to assist in the identification of system functions. Figures 5 and 6 illustrate two examples of typical chemical cargo transfer schemes. Figure 5 represents chemical liquid transfer from the terminal to a tank vessel, and Figure 6 illustrates the transfer of pressurized liquefied chemical gas from a tank vessel to the terminal. The purpose, goals, and objectives of each containment system were delineated in accordance with FJA methodology. Figures 7 and 8 illustrate the functional purposes, goals, and objectives of the ambient pressure-ambient temperature and high pressure-ambient temperature containment systems, respectively. Tasks performed by the person-in-charge of chemical cargo handling on tankships and tank barges were identified, conceptualized and formulated in relation to the purposes, goals

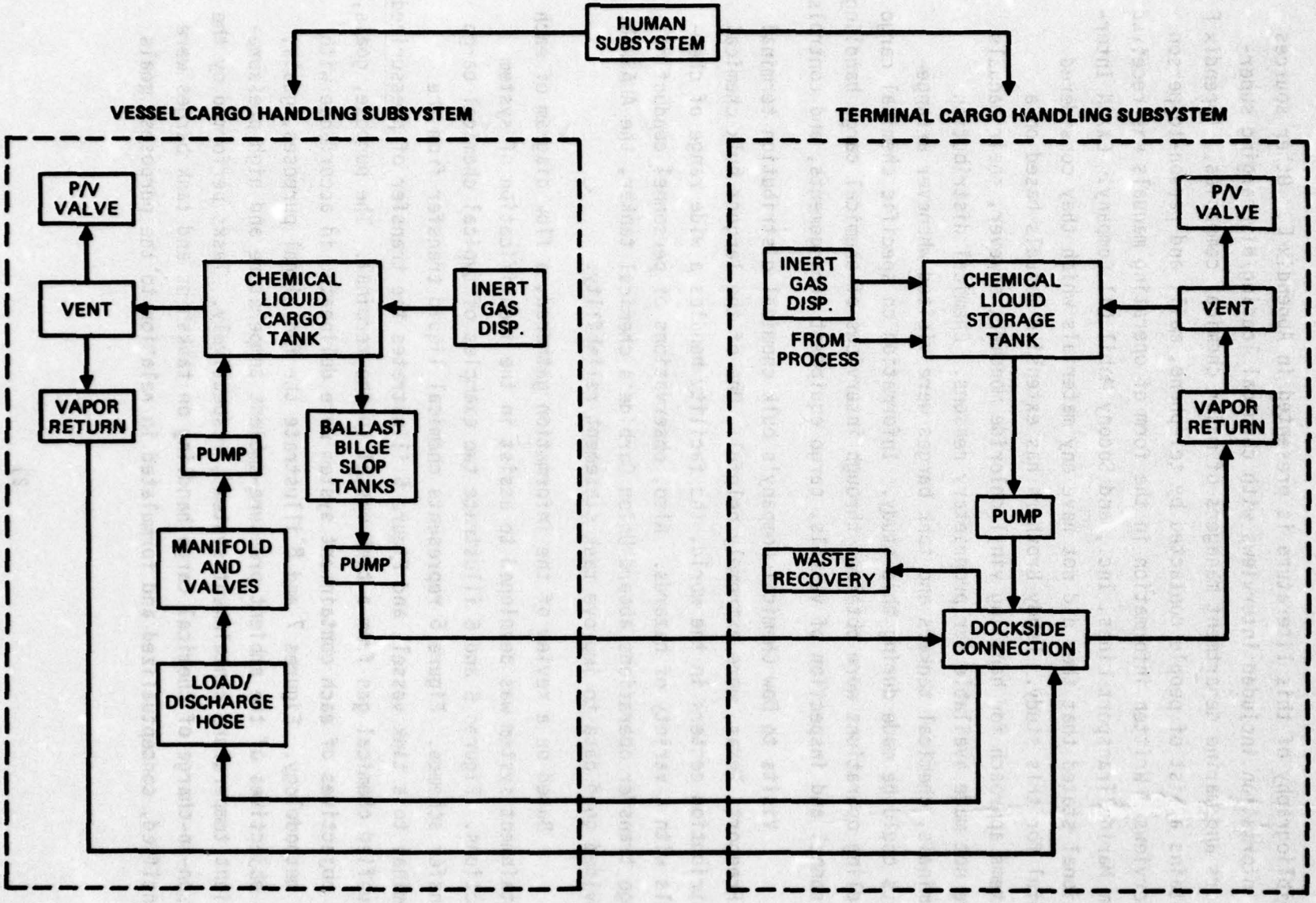

FIGURE 5. MAN-MACHINE INTERRELATIONSHIP
(Simplification of Ambient Pressure-Ambient Temperature Containment System)

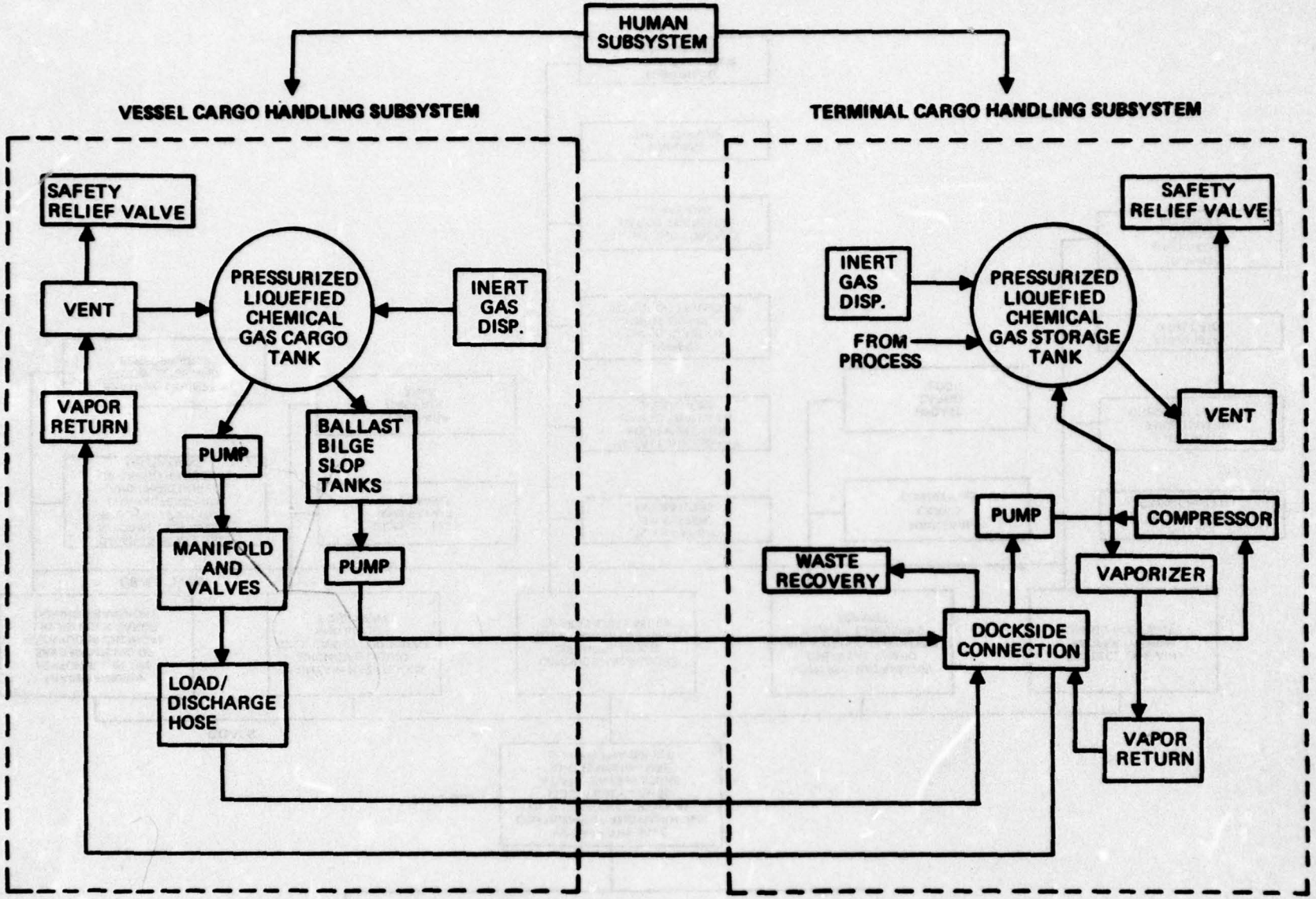

FIGURE 6. MAN-MACHINE INTERRELATIONSHIP
(Simplification of High Pressure-Ambient Temperature Containment System)

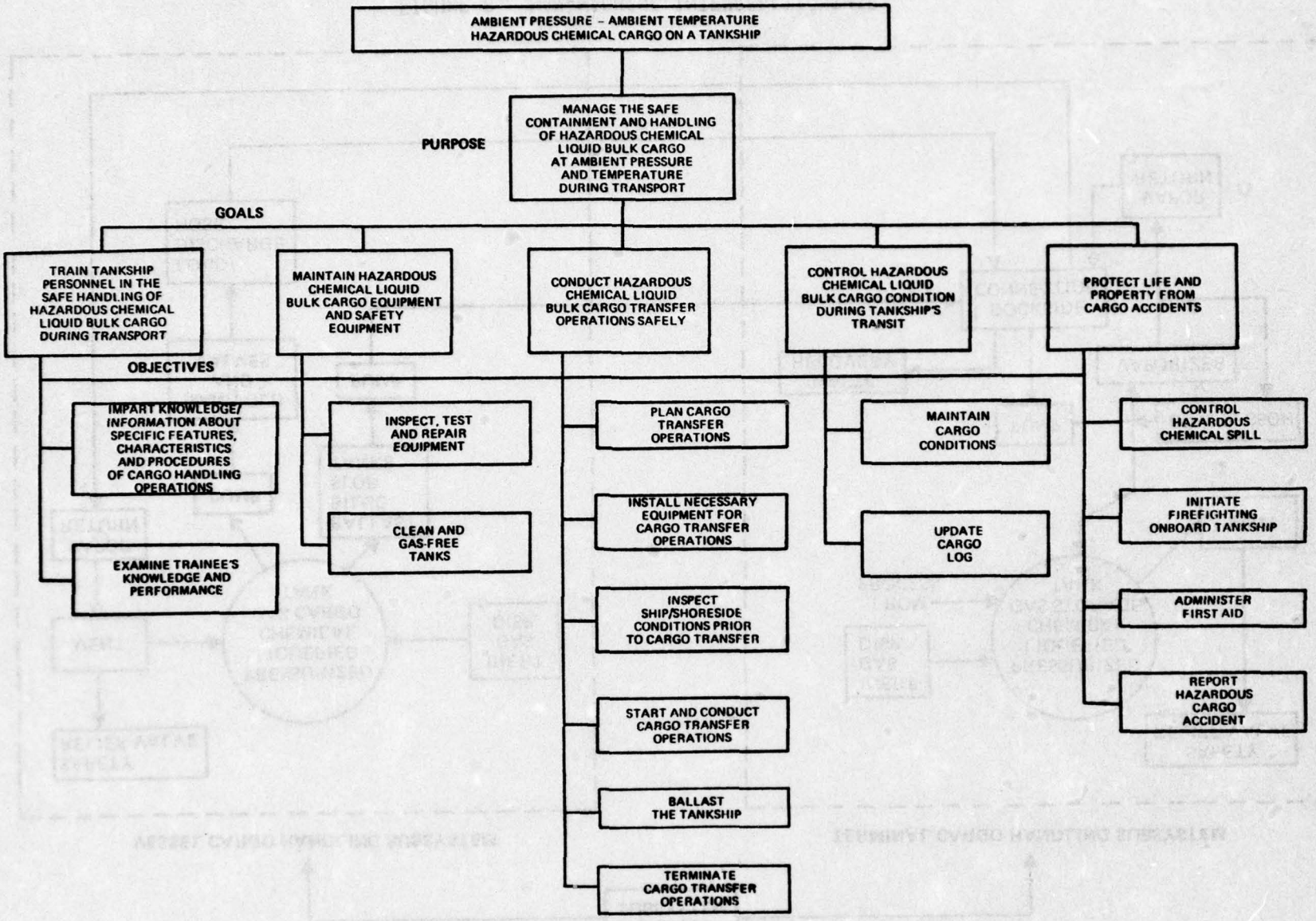

FIGURE 7. FUNCTIONAL PURPOSE, GOALS AND OBJECTIVES FOR AMBIENT PRESSURE-AMBIENT TEMPERATURE CONTAINMENT SYSTEM

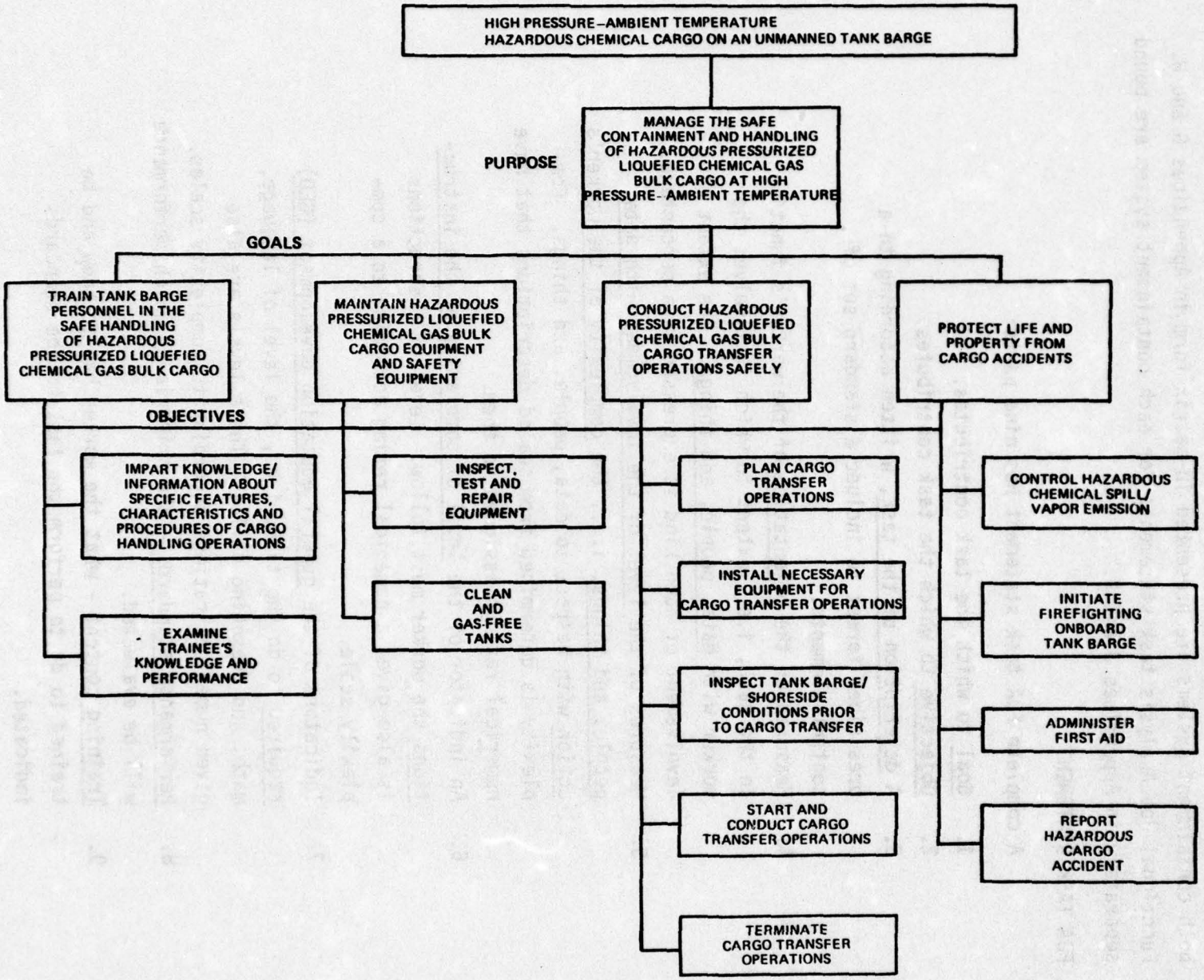

FIGURE 8. FUNCTIONAL PURPOSE, GOALS AND OBJECTIVES FOR HIGH PRESSURE-AMBIENT TEMPERATURE CONTAINMENT SYSTEM

and objectives of the system. Task descriptors and curriculum outlines for both containment systems are presented in matrix form in Appendices G and H. Functional Job Analysis task statements for each containment system are bound separately in Appendices J and K.

FJA TASK STATEMENT

A complete FJA task statement has nine parts:

1. Goal to which the task contributes.
2. Objective to which the task contributes.
3. A description of the task, written according to a prescribed format to include a standard set of content elements.
4. Measures of the orientation of the worker's function in the task, i.e., extent to which it involves the worker with data, people, and things. The extent of involvement of each kind is expressed as a percentage.
5. Measures of the level of the involvement with data, people, and things, i.e., the complexity of the worker's action with respect to data, people, and things. Complexity is determined from scaled descriptions that have numerical ratings assigned to them.
6. An indicator of the level of complexity of the instructions the worker must follow. Level of instructions is also given a numerical rating according to a complexity scale.
7. Indicators of the general education development (GED) required to do the task, i.e., the level of language, math, and reasoning skills. These levels are also given numerical ratings according to complexity scales.
8. Performance standards - the criteria by which performance will be evaluated.
9. Training content - what the worker has to know and be trained to do to perform the task to the standards indicated.

The terms "task statement" and "task statement form" refer to all nine parts or their documentation. "Task description" is the verbal statement of the task only.

Figures 9 and 10 are example FJA task statements for each containment system. Both tasks deal with the operation of cargo controls to start and conduct cargo transfer operations. The example shown in Figure 9 is concerned with an ambient pressure-ambient temperature containment system, and describes starting and regulating chemical liquid flow by controlling the operation of a cargo valve. In contrast, the task statement shown in Figure 10 describes how pressurized liquefied chemical gas flow is controlled by adjusting a cargo valve on the barge and communicating with shoreside personnel controlling a vaporizer to heat the cargo. The scales for both tasks are the same, even though the equipment operation differs in principle. The task statement scales of worker function, instructional level, and general educational development defined in Functional Job Analysis Scales, A Desk Aid, by Sidney A. Fine, are provided for ready reference in Appendix I. The scale ratings for the complexity of task content, instruction, and language/reasoning/math skills provide checks on the accuracy of the task description.

WRITING AN FJA TASK STATEMENT

The goals and objectives have already been defined in the process of delineating system function and are recorded on the task statement forms as appropriate.

Tasks are identified and prepared for each objective. The structure and language prescribed by FJA is used to write a complete description of each task. The other parts of the task statement are completed in turn, using each as a check on the veracity of the preceding parts. When a task statement is well done, the parts complement each other -- they make a sensible and logical whole.

The processes of describing tasks and completing the remainder of the task statement form are explained individually in the following paragraphs. It should be remembered that in the actual performance of this process, it is often necessary to loop back to check and adjust preceding parts.

TASK CODE:									
WORKER FUNCTION LEVEL AND ORIENTATION						WORKER INSTRUCTIONS	GENERAL EDUCATIONAL DEVELOPMENT		
DATA	%	PEOPLE	%	THINGS	%		REASONING	MATH	LANGUAGE
3B	50	1A	5	2B	45	3	4	3	3

TASK CODE:	GOAL: Conduct hazardous chemical liquid bulk cargo transfer operations safely.

OBJECTIVE: Start and conduct cargo transfer operations.

TASK: Operates/controls cargo valves manually or using control panel pushbuttons, observes cargo connections and hose for leakage and operating pressure gage on cargo system, complying with specific cargo loading limitations noted on vessel's certificate of inspection, and following standard operating procedure, using own judgment and knowledge, in order to transfer cargo without leakage to environment.

PERFORMANCE STANDARDS	TRAINING CONTENT
Descriptive: • Starts transfer slowly. • Controls liquid cargo transfer carefully and correctly. Numerical: • In all cases of transfer, no significant amount of liquid is released to the environment. • No overload of individual tanks occurs	Functional: • General knowledge of operating principles of cargo pump, cargo valves, pressure indicators, ullage indicators, etc. • How to operate controls on a control panel. • How to read gages (decimal indicators) • How to read and follow standard operating procedures. Specific: • Knowledge of standard operating procedure and loading limitation on vessel's certificate of inspection. • Knowledge of specific liquid chemical cargo pumping characteristics and hazards. • Knowledge of specific cargo pump operation, cargo valves, cargo pipe connections, pressure indicators, ullage indicators, etc.

FIGURE 9. EXAMPLE FJA TASK STATEMENT - AMBIENT PRESSURE-AMBIENT TEMPERATURE CONTAINMENT SYSTEM

TASK CODE:									
WORKER FUNCTION LEVEL AND ORIENTATION						WORKER INSTRUCTIONS	GENERAL EDUCATIONAL DEVELOPMENT		
DATA	%	PEOPLE	%	THINGS	%		REASONING	MATH	LANGUAGE
3B	50	2	20	2B	30	3	4	3	4

TASK CODE:	GOAL: Conduct hazardous pressurized liquefied gas bulk cargo transfer operations safely.

OBJECTIVE: Start and conduct cargo transfer operations.

TASK: Operates cargo valve (adjusts valve opening by manually turning handwheel) talks on walkie-talkie to shoreside personnel operating control to vaporizer (heat exchanger) to raise temperature of pressurized liquefied gas cargo above ambient condition, following standard operating procedures in order to pressurize and discharge liquefied cargo from tank.

PERFORMANCE STANDARDS	TRAINING CONTENT
Descriptive:	Functional:
• Cargo temperature is controlled carefully and accurately.	• General knowledge of vaporizer operating techniques.
• Maintains effective communciation with personnel.	• How to operate cargo valves read dials.
Numerical:	• How to read and follow standard operating procedures.
• Temperature of pressuirzed liquefied gas cargo is controlled within specified limits in all cases.	• How to communicate with personnel.
	Specific:
	• Knowledge of physical and chemical properties of the specific pressurized liquefied gas.
	• Knowledge of hazards associated with pressurized liquefied gas and additional specific hazards (e.g., flammability, reactivity, toxicity, etc.).
	• Knowledge of specific temperature limits for pressurized liquefied gas cargo.

FIGURE 10. EXAMPLE FJA TASK STATEMENT - HIGH PRESSURE-AMBIENT TEMPERATURE CONTAINMENT SYSTEM

Task Description

The quality of the task statement as a whole flows from the quality of the task description. Consistency, clarity and comparability of task descriptions result from:

- Controlled content elements
- Controlled language to describe content elements.

The FJA procedure provides for both. The developers of FJA have this to say about required content elements: "The two most important elements of a task statement are:

1. The action the worker is expected to perform.
   Example: Asks questions, listens to responses, and writes answers on standard forms.

2. The result expected of the worker action.
   Example: To record basic identifying information such as name, address, etc."

"The worker action(s) phrase in the task description represents the worker's activity as concretely as possible. The result phrase describes explicity what his action is expected to produce or what gets done, which identifies the worker's concrete contribution to a process or work system objective. Although action and result are the two most critical elements in a task description, and can be thought of as the skeleton of a task, the description must include additional items of information to communicate clearly and consistently."[5]

Figure 11 is a checklist excerpted from Fine and Wiley[6] that states all of the information needed in a task description.

The use of language is also important in FJA. Writing task descriptions requires practice in the precise use of terms. The reader of a task should be able to visualize the task clearly.

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[5] An Introduction to Functional Job Analysis, Sidney A. Fine and Wretha W. Wiley, W.E. Upjohn Institute for Employment Research, 1971, p. 10-11.

[6] Ibid.

1. Who? (Subject)

   The subject of a task description is understood to be simply "worker". The description contains no subject since it is always assumed to be "worker".

2. Performs what action? (Action Verb and Object)

   A task description requires a concrete, explicit action verb. Verbs which point to a process (such as develops, prepares, interviews, counsels, evaluates and assesses) should be avoided or used only to designate broad processes, methods, or techniques which are then broken down into explicit, discrete action verbs.

3. To accomplish which immediate results?

   The purpose of the action performed must be explicit so that (1) its relation to a system objective is clear and (2) performance standards for the worker can be set.

4. With what tools, equipment, or work aids?

   A task description should identify the tangible instruments a worker uses as he performs a task; for example, telephone, pencil/paper, checklists, written guides, wrench, etc.

5. A task description should reflect the nature and source of instruction the worker receives. It should indicate what in the task is prescribed by a superior and what is left to the worker's discretion or choice.

FIGURE 11. INFORMATION NEEDED TO DESCRIBE A TASK

Assessment of Task Functional Level and Orientation

After writing the task description, an assessment of the functional level and orientation of the task is required. The following explanation of this step is adapted from Fine and Wiley's Functional Job Analysis, footnoted previously.

What workers do as they perform the tasks that make up their jobs, they do in relation to Data, People, and Things. All jobs involve the workers, to some extent, with information or ideas (Data), with clients or co-workers (People), and with machines or equipment (Things). Workers function in unique ways in each of these areas. For example, when a worker's task involves him with machines or equipment (Things), the worker draws upon his physical resources (strength, dexterity, motor coordination, etc.). When a worker's task involves him with information or ideas (Data), the worker calls his mental resources into play (knowledge, thought, intuition, insight, etc.). When a worker's task involves him with clients, customers, and co-workers (People), the worker draws upon his interpersonal resources (empathy, courtesy, warmth, openness, guile, etc.). All jobs require the worker to relate to each of these areas and in doing so require him to draw upon his resources in each of these areas to some degree.

The three hierarchies of Data, People, and Things functions provide two measures for systematically comparing and measuring the requirements of any task in any job. These two measures are level and orientation.

The level measure indicates the relative complexity or simplicity of a task when it is compared to other tasks. It is expressed by selecting the function that best describes the pattern of behavior in which the worker engages to perform a given task effectively. The ordinal position of the function is the level measure. For example, to say that a worker in dealing with the Data content of a task is compiling, one has indicated that he is functioning at level 3B on the Data scales as shown in Appendix I . This requires a higher level of functioning than is required in copying information (level 2) but it is a lower level function than is required for analyzing data (level 4).

The orientation measure provided by FJA indicates the relative involvement of the worker with Data, People, and Things as he performs a given task. It is unusual for the worker to be equally involved with all three in any given task and his relative involvement with any of the three may change from task to task. For example, in performing one task in his job, a worker may be involved almost exclusively with Data; that is, something like 75 percent of his involvement and the resources he draws upon to perform a task are related to Data at the compiling level; but in order to accomplish the task, he must also be inolved interpersonally in exchanging information with coworkers (perhaps 15 percent) as well as in calling upon physical resources in handling various documents, paper, and pen (10 percent). The worker's total functional involvement with Data (75 percent), People (15 percent), and Things (10 percent) adds up to 100 percent and must always do so.

Assessment of Instructional Level

The next step toward the completion of the task statement deals with worker instructions. All work is a mix of prescription and discretion; whatever is not prescribed is discretionary and vice versa. High level tasks have a greater proportion of discretion in relation to prescription.

The prescribed and discretionary mix of work is described in FJA by an ordinal scale called the Worker Instructions Scale. It will be found following the Worker Function Scales in Appendix I.

Each task description contains information about the instructions the worker received (the prescription) and what is left to the worker to decide (discretion). This information should be adequate to determine the level of instructions on the Worker Instructions Scale.

The instructions rating is compared to the data rating selected from the Worker Function Scale for Data. If there is a difference of more than one level between those two ratings, the two ratings are rechecked. High-level instructions are not appropriate for a low-level data task, and vice versa.

Assessment of Basic Educational Skill Requirements

The Scales of General Educational Development (GED) presented in Appendix I provide a tool for determing the basic educational skill requirements necessary to perform a job at specified Things, Data, and People functional levels. Basic educational skills refer to reasoning, math, and language skills.

The level of skill the task requires in each of these basic areas is critical information to anyone setting qualification standards. The general education requirement for a job can best be set based on the actual requirements of the tasks assigned to workers in the job. Requirements set in this way have a much firmer foundation than those based on academic credentials. For example, "high school diploma" is a meaningless requirement unless it guarantees possession of certain skills (which it often does not), and only then if those skills are actually the ones needed for successful task performance. Arbitrary diploma and degree requirements are no guarantee to an employer and they may screen out capable, motivated people.

The GED Scales in Appendix I are ordinal, like the Worker Function and Worker Instructions Scales, and they are used similarly. The whole task description, but particularly the worker action and the instructions must be considered, as well as, the worker function levels and orientation. Those data should lead naturally to the appropriate GED levels.

Determination of Performance Standards

The next step in completing an FJA task statement is to determine appropriate performance standards. These standards establish the rigor of any qualification testing that may be required. They provide a basis for evaluating the performance of candidates on such tests. The standards also will be important information for the development of training and measures of training outcomes.

Two types of performance standards are defined in FJA: descriptive and numerical. The developers of FJA explain the difference as follows.

Descriptive standards are performance criteria which are generally nonspecific and subjective; e.g., "please type this letter as quickly as

possible;" "be reasonably accurate in checking these figures;" "don't spend too much time in compiling this report;" "be as complete as possible in collecting the information." They tell in general terms which is expected; but they are wide open to interpretation.

Numerical standards are objective performance criteria which require no interpretation. They usually take the form of numerical or categorical statements; e.g., "please have this letter typed by 5:00 P.M.," "please double-check these figures to ensure that there are no errors." Since they are objective, they explicitly communicate the standards by which performance will be assessed.

In a given work situation, most workers learn through experience (which may be quite frustrating), how to interpret descriptive standards correctly and produce acceptable results. However, descriptive standards are inadequate by themselves for use in setting personnel qualifications. There are some tasks for which it is very difficult to specify numerical or categorical standards. However, if it is not possible or appropriate to be explicit about how the worker's action and the results are to be evaluated, then the task should not affect qualifications. In some cases, it might appear that there are no appropriate numerical or categorical standards at first, but they tend to become evident when the descriptive standards are written.

Performance standards are determined according to common sense informed by the task description and the worker function scale levels. The worker orientation measure is also considered. If a task is 80% Thing-oriented, then the standard(s) should be set for the worker's functional level in relation to things. In that case, it is not necessary to set a standard for the results of the involvement with, say, People, unless that involvement, though relatively minor as a percentage of total involvement is critical and is not measured by the standard(s) set for Things results. Such a situation is unlikely, and if it appears, consideration should be given to whether the task is actually two tasks that ought to be separated.

EDIT OF TASK STATEMENTS

Following completion of the task statements, the editing process begins. The purposes of the edit are:

- To assure that all content elements are included and that their wording in the task description is clear.
- To check whether the task description accurately represents the functional level and orientation, the instructional level and the basic skill requirements of the task.
- To check whether the performance standards and training content appear to be usable operationally (by workers, supervisors, and trainers) and are logically supportable in view of the other parts of the task statement.
- To determine whether the whole task statement gives a sense of reality about the task action and its context.

The edit is done by individual editors. The analysts who intially write the task statement may exchange them for this activity, or other people may perform the edit. The editors must be versed in the use of FJA, and it is helpful if they are knowledgeable about the field of the work system. (When the editor is not familiar with the field, he has to question the writer of the task statement more to clarify a task). The editor provides feedback to the analyst in the manner that is most convenient to resolve problems and finalize the task statements for field review. Dr. Sidney Fine played a major role in editing the material developed in this study.

SUBMIT TASK STATEMENTS TO FIELD REVIEW

The purpose of the field review is to validate the task statements by obtaining feedback from the people who are most knowledgeable about the system. In this study, task statements were given to marine department personnel when visiting chemical terminals and vessels. Follow up telephone calls were made to discuss questions raised during the review of task statements.

The field review answers the following questions:

- Do the task statements communicate the same thing to all concerned readers?
- Does everyone concerned agree that the task statements represent reality?

Differences of opinion are resolved by discussion and, when necessary, by writing and comparing task descriptions that reflect the differing opinions.

When the two questions above are answered affirmatively, FJA has created the empirical data necessary for determining personnel qualifications and for performing other kinds of occupational analysis.

APPENDICES

IV. RECOMMENDED FUTURE WORK RELATED TO THIS STUDY

CONTAINMENT SYSTEMS

It is recommended task analyses be performed on the remaining two containment systems defined in this study (i.e., ambient pressure - low temperature and ambient pressure - high temperature). A large part of the work performed in connection with Ambient pressure - low temperature cargo containment was analyzed under task 1b of Human Factors Requirements Contract DOT-CG-41903-A (Analysis of personnel tasks aboard LNG vessels). Additional work is needed, however, to define training requirements for handling other refrigerated liquefied gas chemicals (e.g., anhydrous ammonia) and to specify more detailed training requirements in the form of a curriculum outline. Probably the most important system yet to be analyzed is the ambient pressure-high temperature system, which generally transports solids in a molten state at elevated temperatures (e.g., molten sulfur). The disappearance of the S.S. MARINE SULFUR QUEEN in 1963, a tank vessel of U. S. registry, underlines the need for an assessment of personnel tasks for such a containment system.

PERSONNEL WEARING PROTECTIVE CLOTHING AND EQUIPMENT

During visits to chemical vessels and terminals, it was noticed that a great majority of chemical handlers did not wear personal protective gear when transferring chemical cargo even though equipment was available on the ship or at terminal facilities. Personnel injuries have occurred due to exposure of chemicals and their vapors during handling. It is reasonable to

assume that personnel injury could have been prevented if protective gear had been worn.

A study should be conducted to determine why personnel do not wear available protective gear when exposed to dangerous conditions during chemical cargo handling on tankships and barges. Chemical cargo handling safety is a concept which involves both human and hardware parameters. On the human side, safety-oriented behavior is desirable, while hardware must be effective. Personal attitudes toward wearing protective gear should be identified. Under certain conditions, wearability attitudes may be influenced primarily by physical defects of a device (e.g., face shield fogging of protective masks). Various personal protective clothing and equipment should be examined to define optimum designs and wearability.

One of the goals of the future study would be to estimate the relative impacts of various personnel protective gear design parameters on wearability and to use this information for possibly improving personnel wearing behavior.

APPENDIX A

TYPICAL CHEMICAL BULK CARGOES TRANSPORTED AT AMBIENT PRESSURE AND TEMPERATURE

National Academy of Sciences Hazard Ratings[1]

Chemicals	Fire	Health			Water Pollution			Reactivity			Federal Regulations Classifications
		Vapor Irritant	Liquid or Solid Irritant	Poisons	Human Toxicity	Aquatic Toxicity	Aesthetic Effect	Other Chemicals	Water	Self-Reaction	
Acetic Acid	2	2	3	2	1	2	2	2	0	0	Combustible Liquid, Grade D
Acetic Anhydride	2	3	3	3	1	2	2	3	2	0	Combustible Liquid, Grade D
Acetone Cyanohydrin	1	1	2	4	4	3	3	2	3	0	Combustible Liquid, Grade E, Class B Poison
Acetonitrile	3	1	1	3	2	1	1	2	0	0	Flammable Liquid, Grade C
Acrylonitrile	3	3	1	3	4	3	2	3	0	3	Flammable Liquid, Grade C
Adiponitrile	1	1	1	3	3	2	3	2	0	0	Combustible Liquid, Grade E
Allyl Alchohol	3	3	2	3	2	3	2	2	0	1	Flammable Liquid, Grade C, Class B Poison
Allyl Chloride	3	3	2	3	2	1	2	2	0	1	Flammable Liquid, Grade B, Class B Poison
Aminoetbyl Ethanoline	1	1	3	1	1	1	3	3	0	0	Combustible Liquid, Grade E
Ammonium Hydroxide											Not Listed
Aniline	1	1	1	3	3	2	4	3	0	0	Combustible Liquid, Grade E, Class B Poison
Benzene	3	1	1	3	1	3	2	1	0	0	Flammable Liquid, Grade C
n-Butyl Acrylate	2	1	1	1	1	2	2	2	0	3	Combustible Liquid, Grade D
Butyraldehyde, (n)	3	2	1	2	1	3	3	2	0	1	Flammable Liquid, Grade C
Camphor Oil (light)	2	0	1	1	3	1	2	2	0	0	Combustible Liquid, Grade D
Carbon Disulfide	4	2	2	3	1	2	3	2	0	0	Flammable Liquid, Grade B
Carbon Tetrachloride	0	1	1	2	1	2	2	1	0	0	Not Listed
Chlorobenzene	3	0	1	2	1	3	2	1	0	0	Combustible Liquid, Grade D
Chloroform	1	2	1	2	1	2	2	1	0	0	Not Listed
Chlorohydrins (crude)	2	2	1	3	3	2	2	2	0	0	Combustible Liquid, Grade D
Chlorosulfonic Acid	0	4	4	4	2	3	2	4	4	0	Corrosive Liquid
Cresols	1	2	3	2	3	3	4	2	0	0	Combustible Liquid, Grade E
Crotonaldehyde	3	3	3	3	3	3	3	2	0	1	Flammable Liquid, Grade C
Dichloropropane	3	1	1	3	1	3	2	1	0	0	Flammable Liquid, Grade C
Diethanolamine	1	2	2	2	1	1	2	3	0	0	Combustible Liquid, Grade E
Diethylenetriamene	1	2	2	2	2	2	3	3	0	0	Combustible Liquid, Grade E
Diisopropanolamine	1	2	2	2	2	2	2	3	0	0	Combustible Liquid, Grade E
Epichlorohydrin	3	3	3	4	3	3	2	3	1	2	Combustible Liquid, Grade D, Class B Poison
Ethyl Acrylate	3	3	2	3	2	2	2	2	0	3	Flammable Liquid, Grade C
Ethyl Ether	4	1	0	2	0	1	1	1	0	0	Flammable Liquid, Grade A

[1] Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals, A Tentative Guide, National Academy of Sciences, National Research Council, Washington, D.C., 1970. This report describes a hazard evaluation system based on four main classes of hazards, and further subdivided into ten subclasses. Under each subclass, a numerical rating of 0, 1, 2, 3, and 4 is assigned to indicate the relative degree of potential hazard (zero being the lowest rating).

National Academy of Sciences Hazard Ratings

Chemicals	Fire	Health			Water Pollution			Reactivity			Federal Regulations Classifications
		Vapor Irritant	Liquid or Solid Irritant	Poisons	Human Toxicity	Aquatic Toxicity	Aesthetic Effect	Other Chemicals	Water	Self-Reaction	
2-Ethyl, 3-Propyl Acrolein	2	3	2	2	1	2	2	2	1	2	Combustible Liquid, Grade E
Ethylene Cyanohydrin	1	0	0	2	1	2	2	2	0	0	Combustible Liquid, Grade E
Ethylene Diamine	3	3	3	3	2	3	2	3	0	0	Combustible Liquid, Grade D
Ethylene Dichloride	3	2	2	3	3	2	2	1	0	0	Flammable Liquid, Grade C
Ethyleneimine	3	3	2	4	4	3	3	3	1	3	Flammable Liquid, Grade C
Formaldehyde solution (37-50%)	2	3	2	3	3	3	2	2	0	1	Combustible Liquid, Grades D or E
Formic Acid	1	3	3	3	3	2	2	2	0	0	Combustible Liquid, Grade E
Furfural	2	2	2	3	3	3	2	2	0	1	Combustible Liquid, Grade E
Hydrochloric Acid Aqueous (28-35%)	0	3	3	2	2	2	2	3	0	0	Corrosive Liquid
Hydrofluoric Acid Aqueous (70%)	0	4	4	4	4	3	2	3	0	0	Corrosive Liquid
Isoprene	4	1	1	1	0	1	1	2	0	3	Flammable Liquid
Methyl Acrylate	3	3	2	3	2	2	2	2	0	3	Flammable Liquid, Grade C
Methyl Methacrylate	3	3	2	3	2	2	2	2	0	3	Flammable Liquid, Grade C
Monoethanolamine	1	2	2	2	2	1	2	3	0	0	Combustible Liquid, Grade E
Monoisopropanolamine	1	1	2	1	2	1	2	3	0	0	Combustible Liquid, Grade E
Morpholine	3	1	1	1	2	2	2	3	0	0	Combustible Liquid, Grade D
Motorfuel Antiknock Compounds (tetraethyl lead and mixtures)	2	1	1	2	3	3	3	1	0	3	Combustible Liquid, Grades D or E, Class B Poison
Oleum	0	4	4	3	2	3	2	4	3	0	Corrosive Liquid
Phenol	1	2	3	3	2	3	3	2	0	0	Combustible Liquid, Grade E, Class B Poison
Phosphoric Acid	0	0	3	1	2	3	2	3	0	0	Corrosive Liquid
Propionic Acid	2	2	3	2	2	2	2	2	0	0	Combustible Liquid, Grade D
Styrene Monomer	3	2	2	2	1	3	2	2	0	3	Combustible Liquid, Grade D
Sulfuric Acid	0	2	4	2	2	3	2	4	3	0	Corrosive Liquid
Triethanolamine	1	0	1	1	1	1	2	3	0	0	Combustible Liquid, Grade E
Triethylene Tetramine	1	2	2	1	1	1	3	3	0	0	Combustible Liquid, Grade E
Vinyl Acetate	3	1	1	2	2	1	2	2	0	3	Flammable Liquid, Grade C
Vinylidene Chloride, inhibited	3	2	2	3	0	2	2	2	0	3	Flammable Liquid, Grade A

APPENDIX B

TYPICAL CHEMICAL BULK CARGOES TRANSPORTED AT HIGH PRESSURE-AMBIENT TEMPERATURE

National Academy of Sciences Hazard Ratings

Chemicals	Fire	Health			Water Pollution			Reactivity			Federal Regulations Classifications
		Vapor Irritant	Liquid or Solid Irritant	Poisons	Human Toxicity	Aquatic Toxicity	Aesthetic Effect	Other Chemicals	Water	Self-Reaction	
Acetaldehyde	4	3	1	2	2	3	2	2	0	1	Flammable Liquid, Grade A
Ammonia, anhydrous	1	4	2	2	2	2	2	3	2	0	Nonflammable Compressed Gas (liquefied)
Butadiene, inhibited	4	1	1	1	0	1	1	2	0	3	Flammable Compressed Gas (liquefied)
Chlorine	0	4	2	4	2	3	2	4	1	0	Nonflammable Compressed Gas (liquefied)
Dichlorodifluormethane	0	0	0	1	0	0	0	1	0	0	Nonflammable Compressed Gas (liquefied)
Dimethylamine	4	2	2	2	2	3	2	3	0	0	Flammable Compressed Gas (liquefied)
Ethyl Chloride	4	1	1	1	0	1	1	1	0	0	Flammable Liquid, Grade A
Ethylene Oxide	4	3	3	2	3	2	1	3	1	4	Flammable Liquid, Grade A
Hydrogen Chloride	0	4	3	3	2	2	2	4	2	0	Nonflammable Compressed Gas (liquefied)
Methyl Bromide	1	3	3	4	0	1	2	1	0	0	Class B Poison
Methyl Chloride	4	0	0	2	0	1	0	1	0	0	Flammable Compressed Gas (liquefied)
Monochlorodifluromethane	0	0	0	1	0	0	0	1	0	0	Nonflammable Compressed Gas (liquefied)
Propylene Oxide	4	3	2	2	2	1	1	3	1	3	Flammable Liquid, Grade A
Vinyl Chloride	4	2	1	2	0	0	0	2	0	2	Flammable Compressed Gas (liquefied)

APPENDIX C

CURRICULUM OUTLINE 1

BULK CHEMICAL CARGO AT AMBIENT PRESSURE - AMBIENT TEMPERATURE

I. Chemical Properties, Hazards, and Hazard Control

A. Physical-Chemical Properties and Characteristics

a. Interpretation of chemical liquid technical data indicated on chemical safety guides relating to physical and chemical properties:

1. Definition and explanation of liquid and vapor density.

2. Vapor pressure and viscosity as a function of temperature.

3. Evaporation rate as a function of heat input.

4. Solubility of chemicals in water.

5. Liquid heat capacity and volumetric coefficient of expansion.

b. Behavior of confined liquids and basic principles of fluid mechanics.

B. Chemical Hazards

a. Interpretation of hazard information indicated on safety guides and the significance of hazards outlined below:

1. Fire relating to definition and explanation of flash-point, flammable limits in air, and autoignition point.

2. Health relating to definition and explanation of toxicity by inhalation (threshold limit value, short-term inhalation limits), toxicity by ingestion (lethal dosage), delayed injuries caused by toxicity, symptoms following human exposure to inhaled vapor, swallowed liquid, liquid contact with eyes or skin, vapor irritant characteristics (burns to skin, eyes, exposure time relationships), odor threshold (human sensitivity to odors), masked odors, chemicals that deaden sense of smell.

3. Reactivity relating to definitions and explanations of chemical reactivity such as: reactivity with water, other chemicals, with common materials, self-reaction, polymerization, exothermic reactions, chemical stability (hazardous chemical decomposition, stabilizers/inhibiters), chemical compatability charts.

4. Pollution relating to definitions and explanations of water pollution (aquatic and waterfowl toxicity), biological oxygen demand and significance of the accumulation of pollutants in the food chain, potential hazards of human consumption.

5. Static electricity relating to cause and effect.

C. Hazard Detection and Control

a. Purpose, use, operation and calibration of hazard detection equipment:

1. Portable chemical vapor concentration indicators.

2. Oxygen indicators.

3. Flammable and combustible gas indicators.

b. Purpose of chemical inhibitors/stabilizers:

1. Chemical additive sampling devices.

2. Additive circulation techniques.

II. Containment Design Concepts and Safety Features

A. Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems

a. Cargo tank isolation and vessel hull design.

b. Arrangement of gravity tanks, integral tanks, pumprooms, deepwell pumps, cargo pumps and valves, cargo vents, ballast tanks and piping, slop tanks, cofferdams, voids, empty tanks, sea and ballast valves, overboard discharge valves.

c. Materials of cargo tank construction and tank coatings.

B. Design, Components and Functions of Cargo Containment Control Mechanisms

a. Pressure-vacuum valves, flame screens, gaging devices.

b. Inert cargo pad equipment.

c. Detection equipment.

C. Components and Functions of Safety Instrumentation and Emergency Systems

a. Signals.

b. Automatic and manual features.

c. Temperature and pressure alarms.

d. Remote shutdown valves and switches.

III. Chemical Cargo Equipment Operation and Maintenance

A. Functions of Chemical Cargo Control Instrumentation

a. Operational performance tests on centralized control consoles utilizing:

1. Standard and emergency controls.

2. Monitoring gages and recorder readouts.

3. Loading computers.

4. Pollution monitors.

B. Purpose and Operation of Cargo Equipment

a. Characteristics of hydraulic systems.

b. Principles and functions of deepwell pumps, centrifugal pumps, positive displacement cargo pumps, ballast pumps, cargo tank cleaning machine (butterworth machines).

c. Principles and functions of inert gas systems.

d. Principles and functions of cargo heating systems.

C. Safety Principles and Procedures Relating to Equipment Set-up for Liquid Cargo Transfer

a. Purpose and operation of cargo hose lift and support equipment such as capstans, windlasses, cranes, and loading/discharging arms.

b. Layout of piping systems and cargo hose.

c. Location and identification of components.

d. Proper connection of electrical bonding wire.

e. Installation of scuppers, warning signs, and fire hose.

D. Maintenance of Chemical Cargo Equipment and Safety Equipment

a. Inspection, maintenance, malfunction diagnosis and repair procedures pertinent to liquid cargo equipment.

1. Cargo tanks and slop tanks (Tanks containing cargo residual, cleaning fluids and water).

2. Tank internals (piping, heating coils, remote control valve rods, monitor tubes).

3. Cargo valves and cargo hose.

4. Gaging devices, pressure-vacuum valves and flame screens.

b. Inspection, maintenance, malfunction diagnosis and repair procedures pertinent to equipment connected to cargo and ballast systems.

1. Sea chests, sea valves, sea strainers, and bilge injection valves.

c. Awareness of hazards which may arise during performance of maintenance activities.

1. Cleaning and gas-freeing tanks.
2. Testing cargo pumps, relief valves, cargo piping, and cargo hoses.

d. Disassembly, for inspection and repair, of defective cargo equipment.

1. Gages and valves.
2. Relief devices.
3. Manifold flanges and gaskets.

e. Inspection, maintenance, malfunction diagnosis and repair procedures pertinent to safety equipment.

1. Respiratory protection equipment.
2. Medical kits.
3. Chemical resistant protective clothing.
4. Rescue lines.
5. Explosion proof lamps (portable and fixed).
6. Self-contained and fresh air breathing apparatus.
7. Decontamination shower and eyewash equipment.

IV. Safety and Emergency Procedures

A. Safety Precautions During Chemical Cargo Transfer Operations

a. Supervision of chemical cargo loading/discharging operations.
b. Effects of chemical bulk cargo on vessel stability and seaworthiness.
c. Interpretation of cargo data.
d. Identification of emergency signals.
e. Proper action in event of fire, spill, or vapor emission.

B. Firefighting Techniques and Procedures for Chemical Fires

a. Abnormal behavior of chemical fires.
b. Chemistry of fire and hazards from chemical decomposition.
c. Flammable vapor clouds.
d. Chemical polymerization.
e. Explosions.
f. Control of tank relieving capacity in fires.
g. Types of firefighting equipment and media for chemical fires.
h. Practical firefighting exercises.

C. Purpose and Use of Personnel Protection and Safety Equipment

a. Fresh air breathing apparatus and self-contained breathing apparatus.
b. Detection equipment.
c. Explosion proof lamps and safety matches.

D. First Aid Procedures

a. Personnel exposure to vapor and liquid by:

1. Inhalation.
2. Ingestion.
3. Eye and skin contact.

b. Treatment of shock.

c. Administration of artificial respiration.

d. Equipment and procedures available for reducing the effect of exposures:

1. Wash down.

2. Decontamination.

e. When medical assistance is required.

f. The use of medical reference material such as:

1. First aid handbooks.

2. International Medical Guide for Ships.

3. Medical First Aid Guide for Use in Accidents Involving Dangerous Goods.

V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes

A. Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations Relating to Cargo Operations

a. 46CFR98, special construction, arrangement and provisions for certain dangerous cargoes in bulk.

b. 46CFR151, requirements for unmanned tankbarges carrying certain dangerous cargo in bulk.

c. 46CFR39, regulations for bulk flammable or combustible liquids having lethal characteristics.

d. 46CFR40, regulations for certain flammable or combustible cargoes.

e. 33CFR154-156, water pollution regulations.

B. Purpose and Content of International Shipping Safety Codes and Guides

a. Maritime Dangerous Goods Code.

b. Tanker Safety Guides.

1. International Chamber of Shipping Tanker Safety Guide (Chemicals).

2. International Oil Tanker Terminal Safety Guide.

C. Purpose and Content of Industry Codes and Government Safety Guides

a. Manufacturing Chemists Association chemical safety data sheets

b. Coast Guard Chemical Hazards Response Information System, (CHRIS) Hazardous Chemicals Data.

c. CG-388, Chemical Data Guide for Bulk Shipment by Water.

APPENDIX D

CURRICULUM OUTLINE 2

BULK CHEMICAL CARGO AT HIGH PRESSURE - AMBIENT TEMPERATURE

I. Chemical Properties, Hazards and Hazard Control

A. Physical and Chemical Properties and Characteristics

a. Interpretation of liquefied chemical gas technical data indicated on chemical safety guides relating to physical and chemical properties:

1. Definition and explanation of physical states of chemical gases as a function of temperature and pressure.
2. Critical temperature and pressure.
3. Density and viscosity of gases as a function of temperature.
4. Coefficient of thermal expansion of gases.
5. Specific heats of liquefied gases.
6. Density of liquefied gases as a function of temperature.
7. Latent heat of vaporization.
8. Solubility of gases.

b. Behavior of confined pressurized liquefied gas and fundamental relationships.

1. Ideal gas law.
2. Partial pressure.
3. Compression and liquefaction of gases.
4. Adiabatic flow.

B. Chemical Hazards

a. Hazards associated with pressurized liquefied gas.

1. Large volumes of vapor result from small liquid leaks.
2. Burns on human skin caused by rapid evaporation.

b. Interpretation of hazard information indicated on chemical data safety guides and the significance of hazards outlined below.

1. Fire relating to definitions and explanations of flash-point, flammable limits in air and autoignition point.
2. Health relating to definition and explanation of toxicity by inhalation (threshold limit value, short-term inhalation limits), toxicity by ingestion (lethal dosage), delayed injuries caused by toxicity, symptoms following

human exposure from inhaled vapor, swallowed liquid, liquid contact with eyes or skin, vapor irritant characteristics (burns to skin, eyes, exposure time relationships), odor thresholds (human sensitivity to odors), masked odors, chemicals that deaden sense of smell.

3. Reactivity relating to definitions and explanations of chemical reactivity such as reactivity with water, other chemicals, with common materials, self-reaction, polymerization, exothermic reactions, chemical stability (hazardous chemical decomposition, stabilizers/inhibiters) and chemical compatability charts.

4. Pollution relating to definitions and explanations water pollution (aquatic and waterfowl toxicity), biological oxygen demand, significance of accumulation of pollutants in the food chain, potential hazards of human consumption.

C. Hazard Detection and Control

a. Purpose, use, operation and calibration of hazard detection equipment.

1. Portable chemical vapor concentration indicators.

2. Oxygen indicators.

3. Flammable and combustible gas indicators.

b. Purpose of chemical inhibitors/stabilizers.

1. Use of chemical additive sampling devices.

2. Additive circulation techniques.

II. Containment Design Concepts and Safety Features

A. Mechanical Design Features of Pressurized Liquefied Chemical Gas Cargo Containment and Handling Systems

a. Arrangement of independent pressure vessel cargo tanks, high pressure cargo pumps, high pressure valves, compressors, vaporizers and pressure vessel venting.

b. Materials of pressure vessel cargo tank construction.

B. Design, Components and Functions of Cargo Containment Control Mechanisms

a. High pressure safety relief devices.

b. Inert cargo displacement equipment.

c. Inert cargo pad systems.

d. High pressure gaging devices.

C. Components and Functions of High Pressure Instrumentation and Emergency Systems

a. Signals.

b. Automatic and manual features.

c. Excess flow valves.

d. Temperature and pressure alarms.

e. Remote shutdown valves and switches.

III. Chemical Cargo Equipment Operation and Maintenance

A. Functions of High Pressure Cargo Control Instrumentation

a. Operational performance tests on centralized control consoles utilizing:

1. Standard and emergency controls.

2. Monitoring gages and recorder readouts.

3. Loading computers.

4. Pollution monitors.

B. Purpose and Operation of High Pressure Cargo Equipment

a. Types of compressors used in the compression of gases.

b. Vaporizers.

c. Inert gas equipment.

C. Safety Principles and Procedures Relating to Equipment Set Up for Pressurized Liquefied Gas Cargo Transfer

a. Purpose and operation of cargo hose lift and support equipment such as capstans, windlasses, cranes and loading/discharging arms.

b. Layout of high pressure flexible metallic hose.

c. Location and identification of components.

d. Proper connection of electrical bonding wire.

e. Installation of warning signs and fire hoses.

D. Maintenance of Chemical Cargo Equipment and Safety Equipment

a. Inspection, maintenance, malfunction diagnosis and repair procedures pertinent to high pressure gas cargo equipment.

1. Pressure vessel cargo tanks.

2. Compressors and vaporizers.

3. High pressure cargo valves and safety relief devices.

4. Flexible metallic cargo hose.

b. Awareness of hazards which may arise during performance of maintenance activities.

1. Cleaning and gas-freeing tanks.

2. Testing high pressure pumping equipment, safety relief devices, high pressure piping and cargo hose.

c. Disassembly, for inspection and repair of defective cargo equipment.

1. High pressure valves.

2. Safety relief devices.

3. High pressure manifold flanges and gaskets.

d. Inspection, maintenance, malfunction diagnosis and repair procedures pertinent to safety equipment.

1. Respiratory protection equipment.

2. Medical kits.

3. Chemical resistent protective clothing.

4. Rescue lines.

5. Explosion proof lamps.

6. Self-contained and fresh air breathing apparatus.

7. Decontamination shower and eyewash equipment.

IV. Safety and Emergency Procedures

A. Safety Precautions During Chemical Cargo Transfer Operations

a. Supervision of pressurized liquefied chemical gas cargo loading/discharging operations.

b. Effects of pressurized liquefied chemical gas bulk cargo on vessel stability and sea worthiness.

c. Interpretation of pressurized liquefied chemical gas cargo data.

d. Identification of emergency signals, proper action in event of pressurized liquefied chemical gas fire, spill and vapor emission.

B. Firefighting Techniques and Procedures for Chemical Fires

a. Abnormal behavior of pressurized liquefied chemical gas fires.

b. Chemistry of fire and hazards from chemical decomposition.

c. Flammable vapor clouds.

d. Polymerization.

e. Explosions.

f. Control of pressure vessel tank relieving capacity in fires.

g. Types of firefighting equipment and media for pressurized liquefied chemical gas fires.

h. Practical firefighting exercises.

C. Purpose and Use of Personnel Protection and Safety Equipment

a. Fresh air breathing apparatus.

b. Self-contained breathing apparatus.

c. Detection equipment.

d. Explosion proof lamps and safety matches.

D. First Aid Procedures

a. Personnel exposure to chemical vapor and liquid by:

1. Inhalation.

2. Ingestion.

3. Eye and skin contact.

b. Treatment of Shock.

c. Administration of artificial respiration.

d. Equipment and procedures available for reducing the effect of exposures.

1. Washdown.

2. Decontamination.

e. When medical assistance is required.

f. The use of medical reference material.

1. First Aid Handbooks.

2. International Medical Guide for Ships.

3. Medical First Aid Guide for Use in Accidents Involving Dangerous Goods.

V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes

A. Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations Relating to Cargo Operations

a. 46CFR98, special construction, arrangement and provisions for certain dangerous cargoes in bulk.

b. 46CFR151, requirements for unmanned tankbarges carrying certain dangerous cargo in bulk.

c. 46CFR40, special construction, arrangement and other provisions for carrying certain flammable or combustible dangerous cargoes (i.e., ethylene oxide and propylene oxide).

d. 33CFR154-156, water pollution regulations.

B. Purpose and Content of International Shipping Safety Codes and Guides

a. Maritime Dangerous Goods Code.

b. Tanker Safety Guides.

1. International Chamber of Shipping.

2. Tanker Safety Guide (Chemicals).

C. Purpose and Content of Industry Codes and Government Safety Guides

a. Manufacturing Chemists Association Chemical Safety Data Sheets.

b. Coast Guard Chemical Hazards Response Information System, (CHRIS) Hazardous Chemical Data.

c. CG-388, Chemical Data Guide for Bulk Shipment by Water.

APPENDIX E
LITERATURE REVIEW

1. Barrow, W.W., Capt., USCG, "Programs For Analyzing and Reducing the Influence of Personnel Failure on Marine Casualties," 14th Annual Tanker Conference, May 12-14, 1969, by the Central Committee on Transportation by Water, American Petroleum Institute.

2. Code of Federal Regulations, Title 46, Parts 10-16, Merchant Marine Officers and Seamen.

3. Code of Federal Regulations, Title 46, Subchapter O, Certain Bulk Dangerous Cargoes, Part 151, Unmanned Barges.

4. Congress of the United States, Office of Technology Assessment, "Oil Transportation by Tankers: An Analysis of Marine Pollution and Safety Measures."

5. Hammer, Willie, Handbook of System and Product Safety, Prentice Hall, 1972.

6. Inter-Governmental Maritime Consultative Organization, "Code For The Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk," October 1971.

7. Inter-Governmental Maritime Consultative Organization, "Sub-Committee on Standards of Training and Watchkeeping," 6th Session, 9-13 June 1975.

8. International Chamber of Shipping, "Tanker Safety Guide (Chemicals)," 1975.

9. Leeper, J.H., "Human Error in Merchant Marine Safety," Conference Proceedings on Bulk Transportation of Hazardous Materials by Water in the Future, by the Committee on Hazardous Materials, National Academy of Sciences, Washington, D.C., July 9-10, 1973.

APPENDIX F

PERSONS CONTACTED IN THE CHEMICAL DISTRIBUTION AND MARINE TRANSPORTATION FIELD

1. Mr. Dennis Alsop
   Marine Operations Manager
   Union Carbide
   New York, New York

2. Mr. Mel Anderson
   Marine Department
   Union Carbide
   New York, New York

3. Mr. Ted Anderson
   Hendy Brothers
   Los Angeles, California

4. Mr. Max Carpenter
   Maritime Institute of Technology
   and Graduate Studies
   Linthicum Heights, Marland

5. Capt. C. D. Davies
   Keystone Shipping Co.
   Philadelphia, Pennsylvania

6. Mr. Al DelliPaoli
   Marine Department
   EXXON International
   New York, New York

7. Mr. Chuck Erickson
   Hendy Brothers
   Los Angeles, California

8. Mr. George Feldman
Transportation Department
E.I. Dupont deNemours
Willington, Delaware

9. Mr. Bob Gregg
Marine Department
Dow Chemical U.S.A.
Freeport, Texas

10. Capt. A.L. Gertsen and
Mr. Arthur Bruce (Chief Mate)
Chemical Tanker (Alaskan)

11. Mr. Bill Hammond
Marine Department
PPG Industries
Pittsburgh, Pennsylvania

12. Mr. Walter Kneal
Keystone Shipping Co.
Philadelphia, Pennsylvania

13. Mr. N. J. Shiebel
Fleet Manager
Marine Transport Lines, Inc.
New York, New York

14. Capt. Sid Vass
Vice President in Charge of Operations
Marine Transport Lines, Inc.
New York, New York

The above management representatives were contacted by mail and/or telephone. They provided many useful comments which contributed to the study. In some cases, they arranged interviews with on-the-job personnel (i.e., tankermen, pumpmen, etc.) and allowed interviewers to observe actual cargo handling operations. Their cooperation is appreciated.

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14. U.S. Coast Guard, "A Manual for the Safe Handling of Inflammable and Combustible Liquids," March 1964.

15. U.S. Coast Guard, Rules and Regulations for Tank Vessels, CG-123, January 1973.

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18. U.S. Coast Guard, An Analysis of Oil Outflows due to Tanker Accidents, 1971-1972, Washington, D.C., November 1973.

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20. U.S. Coast Guard, Chemical Response Information System, CHRIS, Hazardous Chemical Data, CG-446, January 1974.

21. U.S. Coast Guard, Fire Fighting Manual for Tank Vessels, CG-329, January 1974.

22. John Wiley & Sons, Inc., International Oil Tanker and Terminal Safety Guide, 2nd edition, 1974.

APPENDIX G

MATRIX OF FJA TASK DESCRIPTORS AND CURRICULUM OUTLINE FOR AMBIENT PRESSURE-AMBIENT TEMPERATURE CHEMICAL CARGO

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features			III. Chemical Cargo Equipment Operation and Maintenance						IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
GOAL I: Train Tankship Personnel in the Safe Handling of Hazardous Chemical Liquid Bulk Cargo During Transport																		
OBJECTIVE I-A: Impart Knowledge/Information About Specific Features, Characteristics and Procedures of Cargo Handling Operations During Transport																		
Task Descriptors:																		
I-A1. Formulates Lesson Plans on Standard Operating Procedures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I-A2. Formulates Lesson Plans on Safety Aspects of Cargo	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I-A3. Recommends Content and Method of Training to Instructors	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I-A4. Presents Lecture/Leads Discussion to Increase Knowledge of Personnel	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I-A5. Provides on-the-job Training Throughout Voyage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I-A6. Posts Standard Sources of Information																X	X	X
I-A7. Orients Personnel to Vessel and Procedures				X	X	X	X	X										
OBJECTIVE I-B: Examine/Evaluate/Observe Trainee's Knowledge and Performance on Site																		
Task Descriptors:																		
I-B1. Tests Trainee's Knowledge	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I-B2. Interviews/Evaluates New Personnel	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
GOAL II: Maintain Hazardous Chemical Liquid Bulk Cargo Equipment and Safety Equipment																		
OBJECTIVE II-A: Inspect, Test and Repair Equipment																		
Task Descriptors:																		
II-A1. Formulates Inspection/Maintenance Schedules	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X
II-A2. Assigns Personnel to Carry Out Inspection/ Maintenance Schedule	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X
II-A3. Reports Faulty Equipment to Manufacturer				X	X	X	X	X	X	X								
II-A4. Replaces/Repairs Defective Equipment When Possible				X	X	X	X	X	X	X								

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS		I. Chemical Properties, Hazards and Hazard Control				II. Containment Design Concepts and Safety Features				III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
		Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Control	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protective and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides
OBJECTIVE II-A, Task Descriptors (Contd.)																			
II-A5.	Tests Fire Detection and Alarm System Sensing Devices						X	X			X								
II-A6.	Tests Cargo Monitoring/Sensing Devices					X	X	X			X								
II-A7.	Checks Respiratory Protection Equipment		X								X			X					
II-A8.	Checks Medical First Aid Equipment		X								X								
II-A9.	Checks Presence/Accessibility of Emergency First Aid Stretchers										X								
II-A10.	Checks Quantity/Accessibility of Personnel Safety/Protective Equipment		X								X			X					
II-A11.	Checks Vapor/Fire Detection Instruments		X	X							X			X					
II-A12.	Inspects Fire Extinguishing Equipment										X			X					
II-A13.	Inspects Fresh Air/Self-contained Breathing Apparatus										X			X					
II-A14.	Inspects Material Condition of Cargo Tanks		X								X								
II-A15.	Inspects Condition of Cargo Valves				X	X					X								
II-A16.	Inspects/Cleans Flame Screens					X					X								
II-A17.	Inspects Condition of Sea Chests, Sea Valves, Sea Strainers, Bilge Injection Valves				X						X								
II-A18.	Inspects Piping Supports, Heating Coils, Valve Rods, Monitor Tubes, etc.				X						X								
II-A19.	Inspects Pressure Vacuum Relief Valves					X					X								
II-A20.	Inspects Cargo Hose										X								
II-A21.	Inspects Power Tools/Electrical Equipment for Safe Design/Approved Type										X								
II-A22.	Inspects Cargo Space Area Where "Hot Work" Will Be Performed		X	X	X						X								
II-A23.	Tests Functioning of Cargo Pump Relief Valves					X					X								
II-A24.	Tests Compressed Air Personnel Safety Equipment										X			X					
II-A25.	Tests Functioning of Decontamination Shower										X			X					

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control					II. Containment Design Concepts and Safety Features			III. Chemical Cargo Equipment Operation and Maintenance					IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes		
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides
OBJECTIVE II-B: Clean and Gas-free Cargo Tanks																				
Task Descriptors:																				
II-B1. Determines if and When Tanks Should Be Cleaned/Gas-freed	X	X	X					X	X	X					X	X	X			
II-B2. Inspects Cargo Tank/Cargo Area to Ensure Safety Before Starting Operations				X	X	X	X	X	X	X					X	X	X			
II-B3. Directs Personnel to Prepare for Cleaning/Gas-freeing Operations	X	X	X	X	X	X	X	X	X	X					X	X	X			
II-B4. Directs Personnel in the Installation of Cleaning Machine		X		X	X			X	X	X					X	X	X			
II-B5. Directs Personnel in Tank Cleaning/Gas-freeing Operations	X	X	X	X	X	X	X	X	X	X						X				
II-B6. Operates Cargo Tank Water Spray Machine		X						X		X						X				
II-B7. Operates Cargo Pump to Transfer Cleaning Liquid/Residue to Slop Tank								X		X						X				
II-B8. Tends Inert Gas or Air Blower Equipment		X						X		X						X				
II-B9. Uses Gas/Vapor Indicators	X	X	X					X		X						X				
GOAL III: Conduct Hazardous Chemical Liquid Bulk Cargo Transfer Operations Safely																				
OBJECTIVE III-A: Plan Cargo Transfer Operations																				
Task Descriptors:																				
III-A1. Communicates with Terminal to Receive Berthing Instructions	X	X		X				X	X											
III-A2. Formulates Cargo Transfer Emergency Procedures	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X			
III-A3. Reads/Evaluates Information to Determine Whether Cargo Loading Should be Permitted	X	X		X					X		X				X	X	X			
III-A4. Plans Sequence of Liquid Cargo Transfer	X	X		X	X	X		X	X		X									
III-A5. Plans Cargo Separation Scheme	X	X		X	X	X		X			X									
III-A6. Selects General Crew Members to Assist Cargo Transfer Operations	X	X		X	X	X	X	X	X		X				X					

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control					II. Containment Design Concepts and Safety Features			III. Chemical Cargo Equipment Operation and Maintenance					IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes		
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Regulations: Cargo and Water Pollution	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides		
OBJECTIVE III-B: Install Necessary Equipment for Cargo Transfer Operations																				
Task Descriptors:																				
III-B1. Directs Personnel in Installation of Necessary Equipment	X	X		X	X	X	X	X	X	X										
III-B2. Connects Vent Piping and Aligns Vapor Return Subsystem	X	X						X	X											
III-B3. Aligns and Seals Sea and Ballast Valves	X	X		X				X	X											
III-B4. Sets Up Firefighting Equipment									X				X							
III-B5. Connects Water Hose									X				X							
III-B6. Posts Warning Signs									X											
III-B7. Calculates Weights for Ship's Tackle									X											
III-B8. Provides Grounding Pathways for Stray Electrical Currents									X								X	X		
III-B9. Plugs Scuppers									X											
III-B10. Connects Vessel/Shore Piping	X	X						X	X											
OBJECTIVE III-C: Inspect Ship and Shoreside Conditions Prior to Cargo Transfer																				
Task Descriptors:																				
III-C1. Verifies Vessel's Certificate of Inspection for the Cargo to be Loaded	X	X							X								X			
III-C2. Inspects Cargo Tank's Gaging Device	X	X				X	X													
III-C3. Checks Shipboard Area for Unauthorized Personnel									X											
III-C4. Inspects Readiness/Accessibility of Fire-fighting Equipment									X				X							
III-C5. Inspects Closure of Sea Valves and Blanking of Unused Pipelines									X	X										
III-C6. Inspects Lighting Sources for Nighttime Transfer Operations									X											
III-C7. Inspects Boiler and Galley Operations	X	X							X											
III-C9. Inspects Cargo Connections	X	X							X	X										

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features					III. Chemical Cargo Equipment Operation and Maintenance					IV. Safety and Emergency Procedures			V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes		
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fire	Purpose and Use of Personnel Protective and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides
OBJECTIVE III-C, Task Descriptors (Contd.)																			
III-C9. Inspects Cargo Tank Openings								X	X										
III-C10. Inspects Deck Areas, Spaces, Openings, etc., Adjacent to Cargo Connections	X	X						X											
III-C11. Determines if and Where Smoking is Permitted	X	X						X											
III-C12. Coordinates Test of Emergency Cargo Control Valves	X	X				X		X	X										
III-C13. Samples Inerting Gas	X	X	X																
III-C14. Checks That No Unauthorized Vessel is Alongside								X											
III-C15. Inspects Spark-generating Equipment								X											
III-C16. Inspects Towing Lines, Receives Information About Equipment Essential for Unberthing if Necessary								X											
III-C17. Inspects/Evaluates Shoreside Facilities								X							X	X	X		
III-C18. Evaluates Data to Determine if Conditions are Safe/Appropriate for Cargo Transfer	X	X						X							X	X	X		
OBJECTIVE III-D: Start and Conduct Cargo Transfer Operations																			
Task Descriptors:																			
III-D1. Directs Personnel in the Initiation and Conduct of Cargo Transfer Operations	X	X		X	X	X	X	X	X										
III-D2. Communicates with Terminal Authorities Concerning Readiness								X											
III-D3. Assures "Declaration of Inspection is Executed Prior to Bulk Cargo Transfer"	X	X						X							X				
III-D4. Starts Operation of Cargo Control Valves, Pumps	X	X		X	X	X	X	X											
III-D5. Checks on Pump Room, Pumps, Valves				X	X	X	X	X		X									
III-D6. Uses Gas Indicator to Determine Toxic Vapor Content of Air	X	X	X	X	X	X													
III-D7. Stops Cargo Transfer Operations in the Event of Severe Weather, Fire, Emergency				X	X	X	X	X											
III-D8. Gathers/Collects/Log Information Concerning Conduct of Cargo Transfer Operations	X	X					X	X	X										

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features					III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
OBJECTIVE III-E: Ballast the Tank Ship																		
Task Descriptors:																		
III-E1. Directs Personnel in Ballasting Operations				X	X	X	X	X	X									
III-E2. Communicates with Terminal Personnel Concerning the Scope/Duration of Ballasting Operations								X	X									
III-E3. Calculates Ballasting Sequence				X	X			X										
III-E4. Lines Up/Energizes Ballast System							X	X										
III-E5. Checks Pump Room, Pumps During Ballasting Operation				X	X			X		X								
OBJECTIVE III-F: Terminate Cargo Transfer Operations																		
Task Descriptors:																		
III-F1. Directs Personnel in the Termination of Cargo Transfer Operations	X	X	X	X	X	X	X	X	X									
III-F2. Controls Cargo Loading Rate to "Top Off" Tank	X	X		X	X	X	X	X										
III-F3. Stops Pumping Operations and Closes Cargo Valves							X	X										
III-F4. Operates Water Cargo Pad Subsystem	X	X			X	X	X	X										
III-F5. Operates Inert Gas Cargo Pad Subsystem	X	X			X	X	X	X										
III-F6. Purge Hose, Lines of Liquid and Vapors	X	X			X	X	X	X	X									
III-F7. Drains Chemical Cargo from Hoses	X	X						X	X									
III-F8. Disconnects Cargo Transfer System Between Vessel and Shore	X	X							X				X					
GOAL IV: Control Hazardous Chemical Liquid Bulk Cargo Condition During Tankship's Transit																		
OBJECTIVE IV-A: Maintain Cargo Conditions																		
Task Descriptors:																		
IV-A1. Maintains Temperature of Cargo within Prescribed Limits	X	X	X		X	X	X	X										
IV-A2. Measures/Checks Stabilizer/Inhibiter Additive Concentration	X	X	X															

CURRICULUM OUTLINE / AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features					III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
OBJECTIVE IV-A, Task Descriptors (Contd.)																		
IV-A3. Circulates Stabilizer/Inhibitor Additive Into Cargo	X	X	X	X	X	X	X	X	X									
IV-A4. Maintain Positive Pressure Above Cargo	X	X	X	X	X	X	X	X										
IV-A5. Maintain Inert Atmosphere in Void Spaces Around Cargo Tanks	X	X	X	X	X	X	X	X										
OBJECTIVE IV-B: Update Cargo Log																		
Task Descriptors:																		
IV-B1. Gathers/Collects Information on Cargo Conditions and Records Data in Log	X	X	X	X	X	X	X	X	X									
GOAL V: *Protect Life and Property from Cargo Accidents*																		
OBJECTIVE V-A: Control Hazardous Chemical Spill																		
Task Descriptors:																		
V-A1. Stops Cargo Transfer Operations				X	X	X	X	X	X									
V-A2. Alerts Shipboard/Terminal Personnel of Spill	X	X	X								X	X	X					
V-A3. Evaluates Type and Extent of Spill	X	X	X	X	X	X	X	X	X		X	X	X					
V-A4. Directs Personnel in Positioning of Fire Hoses				X							X	X	X					
V-A5. Directs Clean-up in Vicinity of Spill	X	X	X	X							X	X	X					
V-A6. Directs the Disconnection of Ship/Shoreside Cargo Lines to Prepare for Possible *Movement Away from Terminal*				X	X				X									
V-A7. Examines Spill Area to Evaluate Extent of Damage	X	X		X	X				X									
OBJECTIVE V-B: Initiate Firefighting Onboard Tankship																		
Task Descriptors:																		
V-B1. Stops Cargo Transfer Operations				X	X	X	X	X	X									
V-B2. Alerts Shipboard/Terminal Personnel of Fire	X	X	X															
V-B3. Evaluates Type and Extent of Fire	X	X	X	X	X	X	X	X	X		X	X	X					
V-B4. Energizes Firemain System								X			X	X						
V-B5. Directs Personnel in Fighting Fire	X	X	X	X	X						X	X	X					

AMBIENT PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS / CURRICULUM OUTLINE	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features			III. Chemical Cargo Equipment Operation and Maintenance							IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical–Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Chemical Liquid Cargo Containment and Handling Systems	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Safety Instrumentation and Emergency Systems	Functions of Chemical Cargo Control Instrumentation	Purpose and Operation of Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set-Up for Liquid Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
OBJECTIVE V-B, Task Descriptors (Contd.)																			
V-B6. Closes Doors, Hatches, Vents, etc., and Checks That Personnel Have Vacated Hazardous Areas				X								X							
V-B7. Directs the Disconnection of Ship/Shoreside Cargo Lines to Prepare for Possible Vessel Movement Away from Terminal	X	X		X	X			X											
V-B8. Examines Damaged Area				X	X			X											
OBJECTIVE V-C: Administers First Aid																			
Task Descriptors:																			
V-C1. Attends to Victims' Burns and Revives Victims														X					
V-C2. Administers Artificial Respiration														X					
V-C3. Treats Victim Suffering from Shock														X					
OBJECTIVE V-D: Report Hazardous Chemical Cargo Accident																			
Task Descriptors:																			
V-D1. Reports Incident According to SOP	X	X		X	X										X				
V-D2. Gathers Information About Incident and Prepares Written Report	X	X		X	X										X				

APPENDIX H

MATRIX OF FJA TASK DESCRIPTORS AND CURRICULUM OUTLINE FOR HIGH PRESSURE-AMBIENT TEMPERATURE CHEMICAL CARGO

CURRICULUM OUTLINE / HIGH PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features						III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical-Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Pressurized Liquefied Chemical Gas Cargo Containment and Handling System	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Pressure Instrumentation and Emergency Systems	Functions of High Pressure Cargo Control Instrumentation	Purpose and Operation of High Pressure Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set Up for Pressurized Liquefied Gas Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
GOAL I: Train Tank Barge Personnel in the Safe Handling of Hazardous Pressurized Liquefied Chemical Gas Bulk Cargo																			
OBJECTIVE I-A: Impart Knowledge/Information About Specific Features, Characteristics and Procedures of Cargo Handling Operations																			
Task Descriptors:																			
I-A1. Presents Information to Clarify Personnel Duties	X	X	X				X	X	X		X		X						
I-A2. Provides on-the-job Training	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
I-A3. Orients Personnel to Procedures				X	X	X	X	X											
OBJECTIVE I-B: Examine/Evaluate/Observe Trainee's Knowledge and Performance on Site																			
Task Descriptors:																			
I-B1. Evaluates Personnel Capabilities in Order to Plan Work Schedule	X	X	X	X	X	X	X	X	X	X	X								
I-B2. Interviews/Evaluates New Personnel	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
GOAL II: Maintain Hazardous Pressurized Liquefied Chemical Gas Bulk Cargo Equipment and Safety Equipment																			
OBJECTIVE II-A: Inspect, Test and Repair Equipment																			
Task Descriptors:																			
II-A1. Reports Faulty Equipment to Manufacturer				X	X	X	X	X	X	X									
II-A2. Replaces/Repairs Defective Equipment When Possible				X	X	X	X	X	X	X									
II-A3. Tests Pressurized Tank Safety Relief Valves				X	X	X	X	X	X	X									
II-A4. Checks Respiratory Protection Equipment		X								X			X						
II-A5. Checks Medical First Aid			X							X									
II-A6. Inspects Fire Extinguishing Equipment										X			X						
II-A7. Inspects Piping Supports, Heating Coils, Valve Rods, Monitor Tubes, etc.				X						X									
II-A8. Inspects External and Internal Condition of Cargo Valves				X	X					X									

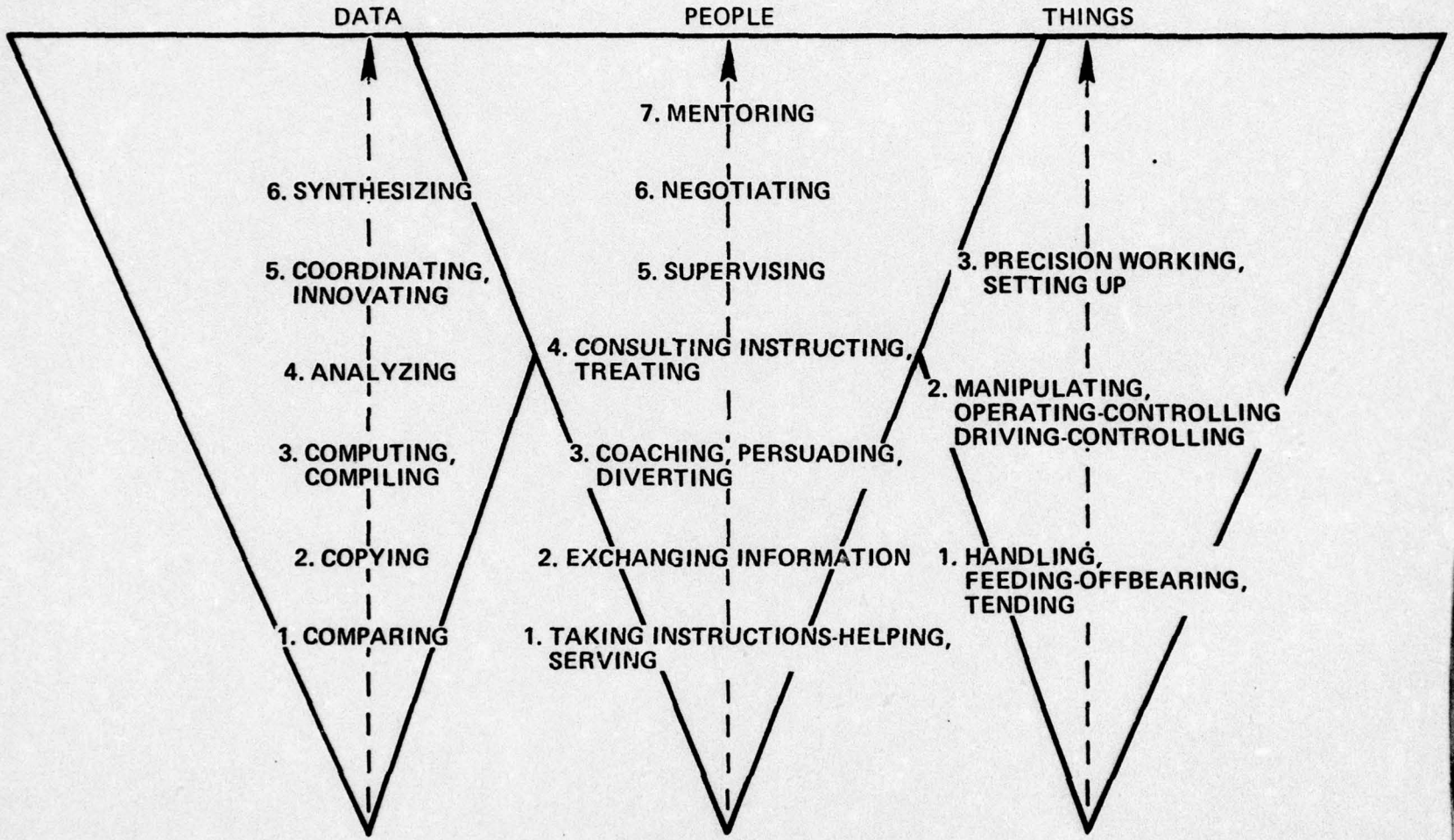
CURRICULUM OUTLINE / HIGH PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features					III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures					V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical-Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Pressurized Liquefied Chemical Gas Cargo Containment and Handling System	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Pressure Instrumentation and Emergency Systems	Functions of High Pressure Cargo Control Instrumentation	Purpose and Operation of High Pressure Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set Up for Pressurized Liquefied Gas Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
OBJECTIVE II-A, Task Descriptors (Contd.)																			
II-A9. Inspects Material Condition of Cargo Tanks		X								X									
II-A10. Inspects Cargo Hose										X									
OBJECTIVE II-B: Clean and Gas-free Cargo Tanks																			
Task Descriptors:																			
II-B1. Determines if and When Tanks Should Be Cleaned/Gas-freed	X	X	X					X	X	X					X	X	X		
II-B2. Reduces Tank Pressure Before Sending Tank Barge off to Shipyard	X	X	X	X	X	X		X											
GOAL III: Conduct Hazardous Pressurized Liquefied Chemical Gas Bulk Cargo Transfer Operations Safely																			
OBJECTIVE III-A: Plan Cargo Transfer Operations																			
Task Descriptors:																			
III-A1. Reads/Evaluates Information to Determine Whether Cargo Loading Should Be Permitted	X	X		X				X		X					X	X	X		
III-A2. Plans Sequence of Cargo Transfer	X	X		X	X	X		X	X		X								
III-A3. Computes Maximum Allowable Working Pressure of Tanks and Cargo Handling System	X	X																X	
III-A4. Selects Personnel to Perform Cargo Transfer Operations	X	X		X	X	X	X	X	X		X				X				
OBJECTIVE III-B: Install Necessary Equipment for Cargo Transfer Operations																			
Task Descriptors:																			
III-B1. Directs Personnel in Installation of Necessary Equipment	X	X		X	X	X	X	X	X	X									
III-B2. Connects Vent Piping and Aligns Vapor Return Subsystem	X	X						X	X										
III-B3. Closes Tank Openings	X	X			X				X										
III-B4. Sets Up Fire Fighting Equipment									X				X						
III-B5. Connects Water Hose									X				X						
III-B6. Posts Warning Signs									X										
III-B7 Provides Grounding Pathways for Stray Electrical Currents									X						X	X			
III-B8. Connects Vessel/Shore Piping	X	X						X	X										

HIGH PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS / CURRICULUM OUTLINE	I. Chemical Properties, Hazards and Hazard Control			II. Containment Design Concepts and Safety Features					III. Chemical Cargo Equipment Operation and Maintenance					IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes		
	Physical-Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Pressurized Liquefied Chemical Gas Cargo Containment and Handling System	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Pressure Instrumentation and Emergency Systems	Functions of High Pressure Cargo Control Instrumentation	Purpose and Operation of High Pressure Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set Up for Pressurized Liquefied Gas Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques for Chemical Fires	Purpose and Use of Personal Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides
OBJECTIVE III-C: Inspect Tank Barge/Shoreside Conditions Prior to Cargo Transfer																				
Task Descriptors:																				
III-C1. Verifies Barge's Certificate of Inspection for Cargo to Be Loaded	X	X						X						X						
III-C2. Checks Barge for Unauthorized Personnel								X												
III-C3. Inspects Readiness/Accessibility of Fire Fighting Equipment								X				X								
III-C4. Inspects Lighting Sources for Nighttime Transfer Operations								X												
III-C5. Checks/Evaluates Reactivity of Pressurized Cargo to Be Loaded with Preceding One	X	X						X									X	X		
III-C6. Checks/Evaluates Suitability of Materials of of Construction of Pressure Tank	X	X						X									X	X		
III-C7. Inspects Cargo Connections and Closure of Openings	X	X		X				X	X											
III-C8. Coordinates Test of Emergency Cargo Control Valves	X	X				X		X	X											
III-C9. Checks that Hose is Certified for Specific Pressurized Cargo	X	X						X												
III-C10. Samples Inerting Gas	X	X	X																	
III-C11. Checks that No Unauthorized Vessel is Alongside								X												
III-C12. Inspects/Evaluates Shoreside Facilities								X							X		X	X		
III-C13. Evaluates Data to Determine if Conditions Are Safe/Appropriate for Cargo Transfer	X	X						X							X		X	X		
OBJECTIVE III-D: Start and Conduct Cargo Transfer Operations																				
Task Descriptors:																				
III-D1. Directs Personnel in the Initiation and Conduct of Cargo Transfer Operations	X	X		X	X	X	X	X	X											
III-D2. Communicates with Terminal Authorities Concerning Readiness								X												
III-D3. Determines if Packaged Goods/Freight Can Be Loaded/Discharged During Loading of Pressurized Cargo	X	X						X												
III-D4. Purges Cargo Handling Subsystem of Air Prior to Loading Pressurized Cargo	X	X				X	X	X												

HIGH PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS / CURRICULUM OUTLINE	I. Chemical Properties, Hazards and Hazard Control					II. Containment Design Concepts and Safety Features			III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes	
	Physical-Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Pressurized Liquefied Chemical Gas Cargo Containment and Handling System	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Pressure Instrumentation and Emergency Systems	Functions of High Pressure Cargo Control Instrumentation	Purpose and Operation of High Pressure Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set Up for Pressurized Liquefied Gas Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides	
OBJECTIVE III-D, Task Descriptors (Contd.)																		
III-D5. Starts Operation of Cargo Control Valves, Pumps	X	X		X	X	X	X	X										
III-D6. Controls Flow of Cargo	X	X		X	X	X	X	X										
III-D7. Controls Pressurization of Cargo	X	X				X	X	X										
III-D8. Responds to Lifting of Relief Valves	X	X		X	X	X	X	X										
III-D9. Responds to Excess Flow Indications	X	X		X	X	X	X	X										
III-D10. Stops Cargo Transfer Operations in the Event of Severe Weather, Fire, Emergency				X	X	X	X	X										
III-D11. Determines if Another Vessel/Barge Can Safely Come Alongside	X	X									X							
III-D12. Gathers/Collects/Logs Information Concerning Conduct of Cargo Transfer Operations	X	X					X	X	X									
OBJECTIVE III-E: Terminate Cargo Transfer Operations																		
Task Descriptors:																		
III-E1. Directs Personnel in the Termination of Cargo Transfer Operations	X	X	X	X	X	X	X	X	X	X								
III-E2. Controls Cargo Loading Rate to "Top Off" Tank	X	X		X	X	X	X	X										
III-E3. Reduces Pressure in Tank After Unloading	X	X			X	X	X	X										
III-E4. Stops Pumping Operations and Closes Cargo Valves							X	X										
III-E5. Operates Water Cargo Pad Subsystem	X	X			X	X	X	X										
III-E6. Operates Inert Gas Cargo Pad Subsystem	X	X			X	X	X	X										
III-E7. Purges Chemicals from Hose and Vent Pipe Lines	X	X			X	X	X	X	X									
III-E8. Drains Chemical Cargo from Hoses	X	X						X	X									
III-E9. Disconnects Cargo Transfer System Between Barge and Shore	X	X							X				X					

CURRICULUM OUTLINE / HIGH PRESSURE–AMBIENT TEMPERATURE GOALS, OBJECTIVES AND TASK DESCRIPTORS	I. Chemical Properties, Hazards and Hazard Control					II. Containment Design Concepts and Safety Features			III. Chemical Cargo Equipment Operation and Maintenance				IV. Safety and Emergency Procedures				V. Proper Procedures and Safety Precautions in Conformance with Government Regulations and Industry Safety Codes		
	Physical-Chemical Properties and Characteristics	Chemical Hazards	Hazard Detection and Control	Mechanical Design Features of Pressurized Liquefied Chemical Gas Cargo Containment and Handling System	Design Components and Functions of Cargo Containment Control Mechanism	Components and Functions of Pressure Instrumentation and Emergency Systems	Functions of High Pressure Cargo Control Instrumentation	Purpose and Operation of High Pressure Cargo Equipment	Safety Principles and Procedures Relating to Equipment Set Up for Pressurized Liquefied Gas Cargo Transfer	Maintenance of Chemical Cargo Equipment and Safety Equipment	Safety Precautions During Chemical Cargo Transfer Operations	Firefighting Techniques and Procedures for Chemical Fires	Purpose and Use of Personnel Protection and Safety Equipment	First Aid Procedures	Purpose and Content of Coast Guard Dangerous Cargo and Water Pollution Regulations	Purpose and Content of International Shipping Safety Codes and Guides	Purpose and Content of Industry Codes and Government Safety Guides
GOAL IV: Protect Life and Property from Cargo Accidents **OBJECTIVE IV-A:** Control Hazardous Pressurized Liquefied Chemical Spill/Vapor Emission **Task Descriptors:** IV-A1. Stops Cargo Transfer Operations				X	X	X	X	X	X										
IV-A2. Alerts Shoreside Personnel of Spill/Emission	X	X	X								X	X	X						
IV-A3. Evaluates Type and Extent of Spill/Emission	X	X	X	X	X	X	X	X	X		X	X	X						
IV-A4. Directs Personnel in Positioning of Fire Hoses				X							X	X	X						
IV-A5. Directs Clean-up in Vicinity of Spill	X	X	X	X							X	X	X						
IV-A6. *Directs Personnel in the Disconnection of* Barge/Shoreside Cargo Lines to Prepare for Possible Movement Away from Terminal				X	X				X										
OBJECTIVE IV-B: Initiate Fire Fighting Onboard Tank Barge **Task Descriptors:** IV-B1. Stops Cargo Transfer Operations				X	X	X	X	X	X										
IV-B2. Alerts Shoreside Personnel of Fire	X	X	X																
IV-B3. Evaluates Type and Extent of Fire	X	X	X	X	X	X	X	X	X		X	X	X						
IV-B4. Energizes Fire Main System								X			X	X							
IV-B5. Directs Personnel in Fighting Fire	X	X	X	X	X						X	X	X						
IV-B6. Directs Personnel in the Disconnection of Barge/Shoreside Cargo Lines to Prepare for Possible Movement Away from Terminal	X	X		X	X				X										
OBJECTIVE IV-C: Administer First Aid **Task Descriptors:** IV-C1. Attends to Victims' Burns and Revives Victims														X					
IV-C2. *Administers Artificial Respiration*														X					
IV-C3. Treats Victim Suffering from Shock														X					
OBJECTIVE IV-D: Report Hazardous Chemical Cargo Accident **Task Descriptors:** IV-D1. Reports Incident According to SOP	X	X		X	X										X				
IV-D2. Gathers Information About Incident and Prepares Written Report	X	X		X	X										X				

APPENDIX I
FJA SCALES



OVERVIEW OF WORKER FUNCTION SCALES